SECTION 3.
STANDARDS FOR PROTECTION AGAINST RADIATION

(FOOTNOTES APPEAR AT THE END OF THIS SECTION)

PART A.
GENERAL

RH-1000. **Authority**. Act 8 of Second Extraordinary Session of 1961, as amended.

RH-1001. **Effective Date**.

The provisions of these Regulations shall become effective on January 1, 1963, except where another effective date is specifically noted.

RH-1002. **Purpose and Scope**.

a. This Section establishes standards for protection against ionizing radiation resulting from activities conducted pursuant to licenses or registrations issued by the Department.

b. It is the purpose of the Regulations in this Section to control the receipt, possession, use, transfer, and disposal of licensed material by any licensee or registrant in such a manner that the total dose to an individual (including doses resulting from licensed and unlicensed radioactive material and from radiation sources other than background radiation) does not exceed the standards for protection against radiation prescribed in the Regulations in this Section. However, nothing in this Section shall be construed as limiting actions that may be necessary to protect health and safety.

RH-1003. **Communications**.

Except where otherwise specified, all communications concerning these Regulations may be addressed to the Arkansas Department of Health, Radiation Control Section, 4815 West Markham Street, Slot 30, Little Rock, Arkansas, 72205-3867.

RH-1004. **Radiation Protection Programs**.

a. Each licensee or registrant shall develop, document, and implement a radiation protection program commensurate with the scope and extent of licensed activities or x-ray equipment use and sufficient to ensure compliance with the provisions of this Section. (See RH-1500. for recordkeeping 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 doses to members of the public 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 in RH-1004.b., and not withstanding the requirements in RH-1208., a constraint on air emissions of radioactive material to the environment, excluding radon-222 and its daughters, shall be established by licensees such that the individual member of the public likely to receive the highest dose will not be expected to receive a total effective dose equivalent in excess of ten (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 RH-1504. and promptly take appropriate corrective action to ensure against recurrence.

RH-1005.- RH-1099. Reserved.

PART B.
DEFINITIONS

RH-1100. **Definitions**.

Absorbed dose - The energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the rad and the gray (Gy).

Accelerator-produced material - Any material made radioactive by a particle accelerator.

Act - Act 8 of Second Extraordinary Session of 1961, as amended.

Activity - The rate of disintegration (transformation or decay of radioactive material). The units of activity are the curie (Ci) and the becquerel (Bq).

Adult - An individual 18 or more years of age.

Agreement State - Any state with which the Atomic Energy Commission or the U.S. Nuclear Regulatory Commission has entered into an effective agreement under subsection 274 b. of the Atomic Energy Act of 1954 (68 Stat. 919), including any amendments thereto. Non-agreement State means any other State.

Airborne radioactive material - Radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases.

Airborne radioactivity area - A room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations:

1. In excess of the derived air concentrations (DACs) specified in Appendix G to Section 3, or

2. To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

Air-purifying respirator - A respirator with an air purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element.

ALARA (acronym for "as low as is reasonably achievable") - Making every reasonable effort to maintain exposures to radiation as far below the dose limits in this Section as is practical consistent with the purpose for which the licensed activity or x-ray equipment use is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of x-ray equipment, nuclear energy and licensed materials in the public interest.

Annual limit on intake (ALI) - 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 5 rems (0.05 Sv) or a committed dose equivalent of 50 rems (0.5 Sv) to any individual organ or tissue. (ALI values for intake by ingestion and by inhalation of selected radionuclides are given in Table I, Columns 1 and 2, of Appendix G to Section 3).

Assigned protection factor (APF) - The expected workplace level of respiratory protection that would be provided by a properly functioning respirator or a class of respirators to properly fitted and trained users. Operationally, the inhaled concentration can be estimated by dividing the ambient airborne concentration by the APF.

Atmosphere-supplying respirator - A respirator that supplies the respirator user with breathing air from a source independent of the ambient atmosphere, and includes supplied-air respirators (SARs) and self-contained breathing apparatus (SCBA) units.

Background radiation - Radiation from cosmic sources, naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material) and global fallout as it exists in the environment from the testing of nuclear explosive devices or from past nuclear accidents such as Chernobyl that contribute to background radiation and are not under the control of the licensee or registrant.

Becquerel (Bq) – One becquerel is equal to one disintegration per second (dps).

Bioassay (radiobioassay) - The determination of kinds, quantities or concentrations and, in some cases, the locations of radioactive material in the human body, whether by direct measurement (in vivo counting) or by analysis and evaluation of materials excreted or removed from the human body.

RH-1100. (Cont'd)

Byproduct material -

1. Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or using special nuclear material;

2. The tailings or wastes produced by the extraction or concentration of uranium or thorium from ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Underground ore bodies depleted by these solution extraction operations do not constitute "byproduct material" within this definition;

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

   B. Any material that:

      i. Has been made radioactive by use of a particle accelerator; and

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

4. Any discrete source of naturally occurring radioactive material, other than source material, that:

   A. The U.S. Nuclear Regulatory Commission, in consultation with the Administrator of the Environmental Protection Agency, the Secretary of Energy, the Secretary of Homeland Security, and the head of any other appropriate Federal agency, determines would pose a threat similar to the threat posed by a discrete source of radium-226 to the public health and safety or the common defense and security; and

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

Class (or lung class or inhalation class) - 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.

Collective dose - The sum of the individual doses received in a given period of time by a specified population from exposure to a specified source of radiation.

Committed dose equivalent ($H_{T,50}$) - The dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

Committed effective dose equivalent ($H_{E,50}$) - The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues ($H_{E,50} = \Sigma w_T H_{T,50}$).

Constraint (dose constraint) - a value above which specified licensee or registrant actions are required.

Controlled area - An area, outside of a restricted area but inside the site boundary, access to which can be limited by the licensee for any reason.

Critical Group - the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances.

Curie (Ci) - One curie is that amount of radioactive material which disintegrates at the rate of 37 billion atoms per second.

Declared pregnant woman - A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception. The declaration remains in effect until the declared woman withdraws the declaration in writing or is no longer pregnant.

Decommission - to remove a facility or site safely from service and reduce residual radioactivity to a level that permits:

1. Release of the property for unrestricted use and termination of the license; or

2. Release of the property under restricted conditions and termination of the license.

Deep-dose equivalent (H_d) - (which applies to external whole-body exposure) The dose equivalent at a tissue depth of one (1) cm (1000 mg/cm^2).

Demand respirator - An atmosphere-supplying respirator that admits breathing air to the facepiece only when a negative pressure is created inside the facepiece by inhalation.

Department - The Arkansas Department of Health or its duly authorized representatives.

Department of Energy (DOE) - The Department of Energy established by the Department of Energy Organization Act (Public Law 95-91, 91 Stat. 565, 42 U.S.C. 7101 et seq.) to the extent that the DOE, or its duly authorized representatives, exercises functions formerly vested in the U.S. Atomic Energy Commission, its Chairman, members, officers, and components and transferred to the U.S. Energy Research and Development Administration and to the Administrator thereof pursuant to Sections 104 (b), (c), and (d) of the Energy Reorganization Act of 1974 (Public Law 93-438, 88 Stat. 1233 at 1237, 42 U.S.C. 5814) and retransferred to the Secretary of Energy pursuant to Section 301(a) of the Department of Energy Organization Act (Public Law 95-91, 91 Stat. 565 at 577-578, 42 U.S.C. 7151).

Derived air concentration (DAC) - 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 (inhalation rate 1.2 cubic meters of air per hour), results in an intake of one ALI. DAC values are given in Table I, Column 3, of Appendix G to Section 3.

Derived air concentration-hour (DAC-hour) - 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 may take 2,000 DAC-hours to represent one ALI, equivalent to a committed effective dose equivalent of 5 rems (0.05 Sv).

Director - Director of the Arkansas Department of Health.

Discrete source – A radionuclide that has been processed so that its concentration within a material has been purposely increased for use for commercial, medical, or research activities.

Disposable respirator - A respirator for which maintenance is not intended and that is designed to be discarded after excessive breathing resistance, sorbent exhaustion, physical damage, or end-of-service-life renders it unsuitable for use. Examples of this type of respirator are a disposable half-mask respirator or a disposable escape-only self-contained breathing apparatus (SCBA).

Distinguishable from background - the detectable concentration of a radionuclide is statistically different from the background concentration of that radionuclide in the vicinity of the site or, in the case of structures, in similar materials using adequate measurement technology, survey, and statistical techniques.

Dose or radiation dose - A generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent, as defined in other Paragraphs of this Section.

Dose equivalent (H_T) - The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv).

Dosimetry processor - An individual or an organization that processes and evaluates individual monitoring equipment in order to determine the radiation dose delivered to the equipment.

Effective dose equivalent (H_E) - The sum of the products of the dose equivalent to the organ or tissue (H_T) and the weighting factors (w_T) applicable to each of the body organs or tissues that are irradiated ($H_E = \Sigma \ w_T H_T$).

Embryo/fetus - The developing human organism from conception until the time of birth.

Entrance or access point - Any location through which an individual could gain access to radiation areas or to radioactive materials. This includes entry or exit portals of sufficient size to permit human entry, irrespective of their intended use.

Exposure - Being exposed to ionizing radiation or to radioactive material.

External dose - That portion of the dose equivalent received from radiation sources outside the body.

Extremity - Hand, elbow, arm below the elbow, foot, knee, and leg below the knee.

Eye dose equivalent - The external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 centimeter (300 mg/cm^2).

Filtering facepiece (dust mask) – A negative pressure particulate respirator with a filter as an integral part of the facepiece or with the entire facepiece composed of the filtering medium, not equipped with elastomeric sealing surfaces and adjustable strap.

Fit factor – A quantitative estimate of the fit of a particular respirator to a specific individual, and typically estimates the ratio of the concentration of a substance in ambient air to its concentration inside the respirator when worn.

Fit test – The use of a protocol to qualitatively or quantitatively evaluate the fit of a respirator on an individual.

Generally applicable environmental radiation standards - Standards issued by the Environmental Protection Agency (EPA) under the authority of the Atomic Energy Act of 1954, as amended, that impose limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material.

Government agency - Any executive department, commission, independent establishment, corporation wholly or partly owned by the United States of America, which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the Government.

Gray - See RH-1102., "Units of Radiation Dose."

Helmet - A rigid respirator inlet covering that also provides head protection against impact and penetration.

High radiation area - An area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in one (1) hour at thirty (30) centimeters from the radiation source or thirty (30) centimeters from any surface that the radiation penetrates.

Hood - A respiratory inlet covering that completely covers the head and neck and may also cover portions of the shoulders and torso.

Individual - Any human being.

Individual monitoring:

1. The assessment of dose equivalent by the use of devices designed to be worn by an individual;

2. The assessment of committed effective dose equivalent by bioassay (see "bioassay") or by determination of the time-weighted air concentrations to which an individual has been exposed, i.e., DAC-hours; or

3. The assessment of dose equivalent by the use of survey data.

Individual Monitoring Devices (individual monitoring equipment) - Devices designed to be worn by a single individual for the assessment of dose equivalent such as film badges, thermoluminescent dosimeters (TLDs), pocket ionization chambers, and personal ("lapel") air sampling devices.

Internal dose - That portion of the dose equivalent received from radioactive material taken into the body.

Lens dose equivalent (LDE) - applies to the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 centimeter (300 mg/cm^2).

License - Except where otherwise specified, a license issued pursuant to these Regulations.

Licensed material - Source material, special nuclear material, or byproduct material received, possessed, used, transferred, or disposed of under a general license provided by regulation or a specific license issued by the Department.

Licensee - The holder of a license.

Limits (dose limits) - The permissible upper bounds of radiation doses.

Loose-fitting facepiece - A respiratory inlet covering that is designed to form a partial seal with the face.

Lost or missing licensed material - Licensed material whose location is unknown. It includes material that has been shipped but has not reached its destination and whose location cannot be readily traced in the transportation system.

Member of the public - Any individual except when that individual is receiving an occupational dose.

Minor - An individual less than 18 years of age.

Monitoring (radiation monitoring, radiation protection monitoring) - The measurement of radiation levels, concentrations, surface area concentrations or quantities of radioactive material and the use of the results of these measurements to evaluate potential exposures and doses.

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

Negative pressure respirator (tight fitting) - A respirator in which the air pressure inside the facepiece is negative during inhalation with respect to the ambient air pressure outside the respirator.

Nonstochastic effect - Health effects, 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 (also called a deterministic effect).

Occupational dose - The dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation or to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include dose received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released in accordance with RH-8420., from voluntary participation in medical research programs, or as a member of the general public.

Particle accelerator - Any machine capable of accelerating electrons, protons, deuterons, or other charged particles in a vacuum and of discharging the resultant particulate or other radiation into a medium at energies usually in excess of 1 megaelectron volt. For purposes of this definition, ''accelerator'' is an equivalent term.

Person -

1. Any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, agency of this state, political subdivision of this state, any other state or political subdivision or agency thereof; and

2. Any legal successor, representative, agent, or agency of the foregoing, but not including United States Government agencies.

Pharmacist - An individual registered by this State to compound and dispense drugs, prescriptions and poisons.

Physician - A doctor of medicine or doctor of osteopathy licensed by the Arkansas State Medical Board to prescribe drugs in the practice of medicine.

Planned special exposure - An infrequent exposure to radiation, separate from and in addition to the annual dose limits.

Positive pressure respirator - a respirator in which the pressure inside the respiratory inlet covering exceeds the ambient air pressure outside the respirator.

Powered air-purifying respirator (PADR) - an air-purifying respirator that uses a blower to force the ambient air through air-purifying elements to the inlet covering.

Pressure demand respirator - a positive pressure atmosphere-supplying respirator that admits breathing air to the facepiece when the positive pressure is reduced inside the facepiece by inhalation.

Public dose - The dose received by a member of the public from exposure to radiation or radioactive material released by a licensee, or to any other source of radiation under the control of a licensee or registrant. Public dose does not include occupational dose or doses received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released in accordance with RH-8420, or from voluntary participation in medical research programs.

Qualitative fit test (QLFT) - A pass/fail fit test to assess the adequacy of respirator fit that relies on the individual's response to the test agent.

Quality Factor (Q) - The modifying factor (listed in Tables 1 and 2 of RH-1102.) that is used to derive dose equivalent from absorbed dose.

Quantitative fit test (QNFT) – An assessment of the adequacy of respirator fit by numerically measuring the leakage into the respirator.

Quarter - 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.

Rad - See RH-1102., "Units of Radiation Dose."

Radiation (ionizing radiation) - Alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as used in this Part, does not include non-ionizing radiation, such as radio- or microwaves, or visible, infrared, or ultraviolet light.

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

Radiation machine - Any device capable of producing radiation, but excluding devices which produce radiation only by the use of radioactive material.

Radioactive material - Any material (solid, liquid or gas) which emits radiation spontaneously including any natural radioactive material such as radium.

Radioactivity - The transformation of unstable atomic nuclei by the emission of radiation.

Reference man - A hypothetical aggregation of human physical and physiological characteristics arrived at 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.

Rem - See RH-1102., "Units of Radiation Dose."

Residual radioactivity - Radioactivity in structures, materials, soils, groundwater, and other media at a site resulting from activities under the licensee's control. This includes radioactivity from all licensed and unlicensed sources used by the licensee, but excludes background radiation. It also includes radioactive materials remaining at the site as a result of routine or accidental releases of radioactive material at the site and previous burials at the site, even if

those burials were made in accordance with the provisions of Part E, "Waste Disposal."

Respiratory protective device - An apparatus, such as a respirator, used to reduce the individual's intake of airborne radioactive materials.

Restricted area - An area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

Sanitary sewerage - 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.

Self-contained breathing apparatus (SCBA) - An atmosphere-supplying respirator for which the breathing air source is designed to be carried by the user.

Shallow-dose equivalent (H_s) - (which applies to the external exposure of the skin of the whole body or the skin of an extremity) - The dose equivalent at a tissue depth of 0.007 centimeter (7 mg/cm^2).

Sievert - See RH-1102., "Units of Radiation Dose."

Site boundary - That line beyond which the land or property is not owned, leased, or otherwise controlled by the licensee.

Source material -

1. Uranium or thorium or any combination of uranium and thorium in any physical or chemical form; or

2. Ores that contain, by weight, one-twentieth of one percent (0.05%), or more, of uranium, thorium, or any combination of uranium and thorium. Source material does not include special nuclear material.

Source of radiation - Any radioactive material or any radiation machine.

Special nuclear material -

1. Plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235, and any other material that the U.S. Nuclear Regulatory Commission, pursuant to the provisions of Section 51 of the Atomic

Energy Act of 1954, as amended, determines to be special nuclear material, but does not include source material, or

2. Any material artificially enriched by any of the foregoing but does not include source material.

Storage container - A device in which sealed sources are transported or stored.

Stochastic effects - Health effects that occur 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.

Supplied-air respirator (SAR) or airline respirator - an atmosphere-supplying respirator for which the source of breathing air is not designed to be carried by the user.

Survey - An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

Temporary jobsite - A location to which radioactive materials or x-ray equipment have been dispatched to perform one (1) or more of the following service operations:

1. Moisture/density measurements;

2. Level measurements;

3. Any portable devices containing radioactive materials; and/or

4. Consulting services included, but not limited to:

   A. Calibration of instruments;

   B. Repair of devices or sources;

   C. Sealed source installation and/or exchange;

   D. Decommissioning of sealed sources.

Tight-fitting facepiece - A respiratory inlet covering that forms a complete seal with the face.

Total Effective Dose Equivalent (TEDE) - The sum of the effective-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Uncontrolled area or unrestricted area - Any area to which access is not controlled by the licensee or registrant for the purposes of protection of individuals from exposure to radiation and radioactive materials and any area used for residential quarters.

Uranium fuel cycle - The operations of milling of uranium ore, chemical conversion of uranium, isotopic enrichment of uranium, fabrication of uranium fuel, generation of electricity by a light-water-cooled nuclear power plant using uranium fuel, and reprocessing of spent uranium fuel to the extent that these activities directly support the production of electrical power for public use. Uranium fuel cycle does not include mining operations, operations at waste disposal sites, transportation of radioactive material in support of these operations, and the reuse of recovered non-uranium special nuclear and byproduct materials from the cycle.

User seal check (fit check) - An action conducted by the respirator user to determine if the respirator is properly seated to the face. Examples include negative pressure check, positive pressure, irritant smoke check, or isoamyl acetate check.

Very high radiation area - 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 grays) in one (1) hour at one (1) meter from a radiation source or from any surface that the radiation penetrates.

Note: At very high doses received at high dose rates, units of absorbed dose (e.g., rads and grays) are appropriate, rather than units of dose equivalent (e.g., rems and sieverts).

Waste - Those low-level radioactive wastes containing source, special nuclear, or byproduct material that are acceptable for disposal in a land disposal facility. For the purposes of this definition, low-level radioactive waste means radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material as defined in paragraphs 2., 3., and 4. of the definition of byproduct material set forth in this section.

Week - Seven (7) consecutive days starting on Sunday.

Weighting factor (w_T) - For an organ or tissue (T) is 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 equivalent, the values of w_T are:

ORGAN DOSE WEIGHTING FACTORS

Organ or Tissue	**w_T**
Gonads	0.25
Breast	0.15
Red bone marrow	0.12
Lung	0.12
Thyroid	0.03
Bone surfaces	0.03
Remainder	0.30[a]
Whole Body	1.00[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.

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

Worker - An individual engaged in work under a license or registration issued by the Department and controlled by a licensee or registrant.

Working level (WL) - Any combination of short-lived radon daughters (for radon-222: polonium-218, lead-214, bismuth-214, and polonium-214; and for radon-220: polonium-216, lead-212, bismuth-212, and polonium-212) in one liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha particle energy.

RH-1100. (Cont'd)

Working level month (WLM) - An exposure to one working level for 170 hours (2,000 working hours per year/12 months per year = approximately 170 hours per month).

Year - The period of time beginning in January used to determine compliance with the provisions of this Section. The licensee may change the starting date of the year used to determine compliance by the licensee provided that the change is made at the beginning of the year and that no day is omitted or duplicated in consecutive years.

RH-1101. Reserved.

RH-1102. **Units of Radiation Dose**.

As used in this Section, the units of radiation dose are:

a. **Exposure rate** - The exposure per unit of time, such as roentgen per minute and milliroentgen per hour.

b. **Gray** (Gy) - The SI unit of absorbed dose. One gray is equal to an absorbed dose of one (1) joule/kilogram (100 rads).

c. **Rad** - The special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram or 0.01 joule/kilogram (0.01 gray).

d. **Rem** - The special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor (1 rem = 0.01 sievert).

e. **Roentgen** - The special unit of exposure. One roentgen (R) equals 2.58 X 10^{-4} coulombs/kilogram of air (See "Exposure" in RH-1100).

f. **Sievert** (Sv) - The SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv = 100 rems).

g. As used in this Section, the quality factors for converting absorbed dose to dose equivalent are shown in Table I to RH-1102.

TABLE I TO RH-1102.
QUALITY FACTORS AND ABSORBED DOSE EQUIVALENCIES

Type of Radiation	**Quality Factor (Q)**	**Absorbed Dose Equal to a Unit Dose Equivalent[a]**
X-, gamma, or beta radiation	1	1
Alpha particles, multiple-charged particles, fission fragments, and heavy particles of unknown charge	20	0.05
Neutrons of unknown energy	10	0.1
High-energy protons	10	0.1

[a] Absorbed dose in rad equal to 1 rem or the absorbed dose in gray equal to 1 sievert.

h. If it is more convenient to measure the neutron fluence rate than to determine the neutron dose equivalent rate in rems per hour or sieverts per hour, as provided in RH-1102.g. of this section, 1 rem (0.01 Sv) of neutron radiation of unknown energies may, for purposes of the Regulations in this Section, be assumed to result from a total fluence of 25 million neutrons per square centimeter incident upon the body. If sufficient information exists to estimate the approximate energy distribution of the neutrons, the licensee may use the fluence rate per unit dose equivalent or the appropriate Q value from Table II to RH-1102. to convert a measured tissue dose in rads to dose equivalent in rems.

RH-1102.h. (Cont'd)

TABLE II TO RH-1102.
MEAN QUALITY FACTORS, Q, AND FLUENCE PER UNIT DOSE EQUIVALENT FOR MONOENERGETIC NEUTRONS

	Neutron Energy (MeV)	**Quality Factor[a] (Q)**	**Fluence per Unit Dose Equivalent[b] (neutrons cm^{-2} rem^{-1})**
(thermal)……	2.5×10^{-8}	2	980×10^{6}
	1×10^{-7}	2	980×10^{6}
	1×10^{-6}	2	810×10^{6}
	1×10^{-5}	2	810×10^{6}
	1×10^{-4}	2	840×10^{6}
	1×10^{-3}	2	980×10^{6}
	1×10^{-2}	2.5	1010×10^{6}
	1×10^{-1}	7.5	170×10^{6}
	5×10^{-1}	11	39×10^{6}
	1	11	27×10^{6}
	2.5	9	29×10^{6}
	5	8	23×10^{6}
	7	7	24×10^{6}
	10	6.5	24×10^{6}
	14	7.5	17×10^{6}
	20	8	16×10^{6}
	40	7	14×10^{6}
	60	5.5	16×10^{6}
	1×10^{2}	4	20×10^{6}
	2×10^{2}	3.5	19×10^{6}
	3×10^{2}	3.5	16×10^{6}
	4×10^{2}	3.5	14×10^{6}

[a] Value of quality factor (Q) at the point where the dose equivalent is maximum in a 30 cm diameter cylinder tissue-equivalent phantom.

[b] Monoenergetic neutrons incident normally on a 30 cm diameter cylinder tissue-equivalent phantom.

RH-1103. **Units of Radioactivity**.

For the purposes of this Part, activity is expressed in the special unit of curies (Ci) or in the SI unit of becquerels (Bq), or their multiples, or disintegrations (transformations) per unit of time.

a. One becquerel = 1 disintegration per second (s^{-1}).

RH-1103. (Cont'd)

b. One curie = 3.7×10^{10} disintegrations per second = 3.7×10^{10} becquerels = 2.22×10^{12} disintegrations per minute.

RH-1104. **Interpretations**.

Except as specifically authorized by the Department in writing, no interpretations of the meaning of the regulations in this Section by an officer or employee of the Department other than a written interpretation by the Department Director or designee will be recognized as binding upon the Department.

RH-1105. **Implementation**.

a. The applicable section of RH-1000. through RH-2110. must be used in lieu of requirements in the standards for protection against radiation in effect prior to January 1, 1994 that are cited in license conditions except as specified in RH-1105.c. through RH-1105.e. of this section. If the requirements of this Section are more restrictive than the existing license condition, then the licensee shall comply with this Section unless exempted by RH-1105.d. of this section.

b. Any existing license condition that is more restrictive than a requirement in RH-1000. through RH-2110. remains in force until there is a license amendment or license renewal.

c. If a license condition exempted a licensee from a requirement in the standards for protection against radiation in effect prior to January 1, 1994, it continues to exempt a licensee from the corresponding provision of RH-1000. through RH-2110.

d. If a license condition cites provisions in requirements in the standards for protection against radiation in effect prior to January 1, 1994 and there are no corresponding provisions in RH-1000. through RH-2110., the license condition remains in force until there is a license amendment or license renewal that modifies or removes this condition.

e. Any existing license condition that is more restrictive than a requirement in RH-1000. through RH-2110. remains in force until there is a technical specification change, license amendment, or license renewal.

f. If a license condition exempts a licensee from a provision of this Section in RH-1. through RH-602., it also exempts the licensee from the corresponding provision in RH-1000. through RH-2110.

RH-1105. (Cont'd)

g. If a license condition cites provisions in the former Part M of Section 3 (currently Appendices A, B, E-H, and J of Section 3 and Appendix A of Section 4) and there are no corresponding provisions in RH-1000. through RH-2110., then the license condition remains in force until there is a license amendment or license renewal that modifies or removes this condition.

RH-1106- RH-1199. Reserved.

PART C.
PERMISSIBLE DOSES, LEVELS, AND CONCENTRATIONS

RH-1200. **Occupational Dose Limits for Adults**.

a. The licensee or registrant shall control the occupational dose to individual adults, except for planned special exposures under RH-1205, to the following dose limits.

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

A. The total effective dose equivalent being equal to 5 rems (0.05 Sv), 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 50 rems (0.5 Sv).

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

A. An lens dose equivalent of 15 rems (0.15 Sv), and

B. A shallow-dose equivalent of 50 rems (0.50 Sv) to the skin of the whole body or to skin of any extremity.

b. Doses received in excess of the annual limits, including doses received during accidents, emergencies, and planned special exposures, must be subtracted from the limits for planned special exposures that the individual may receive during the current year (See RH-1205.e.1.) and during the individual's lifetime (See RH-1205.e.2.).

RH-1200. (Cont'd)

c. When the external exposure is determined by measurement with an external personal monitoring device, the deep-dose equivalent must be used in place of the effective dose equivalent, unless the effective dose equivalent is determined by a dosimetry method approved by the Department. The assigned deep-dose equivalent must be for the part of the body receiving the highest exposure. The assigned shallow-dose equivalent must be the dose averaged over the contiguous ten (10) square centimeters of skin receiving the highest exposure. The deep-dose equivalent, lens-dose equivalent, and shallow-dose equivalent may be assessed from surveys or other radiation measurements for the purpose of demonstrating compliance with the occupational dose limits, if the individual monitoring device was not in the region of highest potential exposure, or the results of individual monitoring are unavailable.

d. Derived air concentration (DAC) and annual limit on intake (ALI) values are presented in Table I of Appendix G to Section 3 and may be used to determine the individual's dose (See RH-1500.f.) and to demonstrate compliance with the occupational dose limits.

e. In addition to 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 c of Appendix G to Section 3.)

f. The licensee 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 RH-1500.d.5.).

RH-1201. **Compliance with Requirements for Summation of External and Internal Doses**.

a. If the licensee is required to monitor under both RH-1302.a. and b., the licensee shall demonstrate compliance with the dose limits by summing external and internal doses. If the licensee is required to monitor only under RH-1302.a. or only under RH-1302.b., then summation is not required to demonstrate compliance with the dose limits. The licensee may demonstrate compliance with the requirements for summation of external and internal doses by meeting one of the conditions specified in RH-1201.b. and the conditions in RH-1201.c. and RH-1201.d.

NOTE: The dose equivalents for the lens of the eye, the skin, and the extremities are not included in the summation, but are subject to separate limits.

RH-1201. (Cont'd)

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[1/] organs or tissues (T) calculated from bioassay data using appropriate biological models and expressed as a fraction of the annual limit.

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

d. **Intake through wounds or absorption through skin**. The licensee 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.

RH-1202. **Determination of External Dose From Airborne Radioactive Material**.

Licensees shall, when determining the dose from airborne radioactive material, include the contribution to the deep-dose equivalent, eye dose equivalent, and shallow-dose equivalent from external exposure to the radioactive cloud. (See Appendix G to Section 3, footnotes a and b.)

NOTE: Airborne radioactivity measurements and DAC values should 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 should be based upon measurements using instruments or individual monitoring devices.

RH-1203. **Determination of Internal Exposure**.

a. For purposes of assessing dose used to determine compliance with occupational dose equivalent limits, the licensee shall, when required under RH-1302., 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 RH-1303.f.5., or the assessment of intake is based on bioassays, the licensee shall assume that an individual inhales radioactive material at the airborne concentration in which the individual is present.

c. When specific information on the physical and biochemical properties of the radionuclides taken into the body or the behavior or the material in an individual is known, the licensee may:

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

2. Upon prior approval of the Department, adjust the DAC or ALI values to reflect the actual physical and chemical characteristics of airborne radioactive material (e.g., aerosol size distribution or density); and

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

d. If the licensee chooses to assess intakes of Class Y material using the measurements given in RH-1203.a.2. or 3., the licensee may delay the recording and reporting of the assessments for periods up to seven (7) months, unless otherwise required by RH-1502. or RH-1504., in order to permit the licensee 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 must be either:

1. The sum of the ratios of the concentration to the appropriate DAC value (e.g., D, W, Y) from Appendix G to Section 3 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 must be the most restrictive DAC of any radionuclide in the mixture.

g. When a mixture of radionuclides in air exists, licensees may disregard certain radionuclides in the mixture if:

1. The licensee uses the total activity of the mixture in demonstrating compliance with the dose limits in RH-1200. and in complying with the monitoring requirements in RH-1302.b.;

2. The concentration of any radionuclide disregarded is less than ten percent (10%) of its DAC; and

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

h. 1. In order to calculate the committed effective dose equivalent, the licensee 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 rems (0.05 Sv) for radionuclides that have their ALIs or DACs based on the committed effective dose equivalent.

RH-1203.h. (Cont'd)

2. When the ALI (and the associated DAC) is determined by the nonstochastic organ dose limit of 50 rems (0.5 Sv), the intake of radionuclides that would result in a committed effective dose equivalent of 5 rems (0.05 Sv) (the stochastic ALI) is listed in parentheses in Table I of Appendix G to Section 3.

   In this case, the licensee may, as a simplifying assumption, use the stochastic ALIs to determine committed effective dose equivalent. However, if the licensee uses the stochastic ALIs, the licensee must also demonstrate that the limit in RH-1200.a.1.B. is met.

RH-1204. Reserved.

RH-1205. **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 RH-1200. 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) specifically authorizes the planned special exposure, in writing, before the exposure occurs.

c. Before a planned special exposure, the licensee or registrant ensures that the individuals involved are:

   1. Informed of the purpose of the planned operation;

   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.

RH-1205. (Cont'd)

d. Prior to permitting an individual to participate in a planned special exposure, the licensee or registrant ascertains prior doses as required by RH-1500.d. during the lifetime of the individual for each individual involved.

e. Subject to RH-1200.b., the licensee or registrant does 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 RH-1200.a., in any year; and

2. Five (5) times the annual dose limits in RH-1200.a. during the individual's lifetime.

f. The licensee or registrant maintains records of the conduct of a planned special exposure in accordance with RH-1500.e. and submits a written report in accordance with RH-1504.

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 thirty (30) days from the date of the planned special exposure. The dose from planned special exposures is not to be considered in controlling future occupational dose of the individual under RH-1200.a. but is to be included in evaluations required by RH-1205.d. and e.

RH-1206. **Occupational Dose Limits for Minors**.

The annual occupational dose limits for minors are ten percent (10%) of the annual dose limits specified for adult workers in RH-1200.

RH-1207. **Dose Equivalent to an Embryo/Fetus**.

a. The licensee or registrant shall ensure that the dose equivalent to the embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, does not exceed 0.5 rem (5 mSv). (For recordkeeping requirements, see RH-1500.f.)

RH-1207. (Cont'd)

b. The licensee or registrant shall make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman so as to satisfy the limit in paragraph a of this section.

c. The dose equivalent to the embryo/fetus is the sum of:

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

2. The dose equivalent to the embryo/fetus resulting 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 the pregnancy to the licensee or registrant, the licensee or registrant shall be deemed to be in compliance with RH-1207.a. if the additional dose to the embryo/fetus does not exceed 0.05 rem (0.5 mSv) during the remainder of the pregnancy.

RH-1208. **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 millisievert) in a year, exclusive of the dose contribution from the background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released in accordance with RH-8420., from voluntary participation in medical research program, and from licensee's disposal of radioactive material into sanitary sewerage in accordance with RH-1402.; and

2. The dose in any unrestricted area from external sources, exclusive of the dose contributions from patients administered radioactive material and released in accordance with RH-8420., does not exceed 0.002 rem (0.02 millisievert) in any one hour.

b. If the licensee or registrant permits members of the public to have access to controlled areas, the limits for members of the public continue to apply to those individuals.

c. Notwithstanding RH-1208.a.1. of this section, a licensee may permit visitors to an individual who cannot be released, under RH-8420., to receive a radiation dose greater than 0.1 rem (1 mSv) if:

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

2. The authorized user, as defined in Section 9, has determined before the visit that it is appropriate; and

3. Documentation shall be maintained by the licensee.

d. A licensee or license applicant or registrant may apply for prior Department authorization to operate up to an annual dose limit for an individual member of the public of 0.5 rem (5 mSv). The licensee or license applicant or registrant shall include the following information in this application:

1. Demonstration of the need for and the expected duration of operations in excess of the limit in RH-1208.a. of this section;

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 as low as is reasonably achievable.

e. In addition to the requirements of this Section, a licensee subject to the provisions of EPA's generally applicable environmental radiation standards in 40 CFR Part 190 shall comply with those standards.

f. The Department may impose additional restrictions on radiation levels in unrestricted areas and on the total quantity of radionuclides that a licensee may release in effluents in order to restrict the collective dose.

RH-1209. **Compliance with Dose Limits for Individual Members of the Public**.

a. The licensee or registrant shall make or cause to be made, as appropriate, surveys of radiation levels in unrestricted and controlled areas and radioactive materials in effluents released to unrestricted and controlled areas to demonstrate compliance with the dose limits for individual members of the public in RH-1208.

b. A licensee or registrant shall show compliance with the annual dose limit in RH-1208. 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 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 G to Section 3; and

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

c. Upon approval from the Department, the licensee may adjust the effluent concentration values in Table II of Appendix G to Section 3 for members of the public, to take into account the actual physical and chemical characteristics of the effluents (e.g., aerosol size distribution, solubility, density, radioactive decay equilibrium, chemical form).

RH-1210. Deleted.

RH-1211. **Orders Requiring Furnishing of Bioassay Services**.

Where necessary or desirable in order to aid in determining the extent of an individual's exposure to concentrations of radioactive material, the Department may require a licensee to make available to the individual appropriate bioassay services and to furnish a copy of the reports of such services to the Department.

RH-1212. **Testing for Leakage and/or Contamination of Sealed Sources**.

a. A licensee possessing any sealed radioactive source under the provisions of a specific license, except as specified in paragraph b. of this section, shall assure that:

1. Each sealed source is tested for leakage and/or contamination and the test results are received before the sealed source is put into use unless the licensee has a certificate from the transferor indicating that the sealed source was tested within the interval listed in the Sealed Source and Device Registry prior to transfer to the licensee;

2. Each sealed source that is not designed to emit alpha particles is tested for leakage and/or contamination at intervals not to exceed those listed in the Sealed Source and Device Registry;

3. Each sealed source that is designed to emit alpha particles is tested for leakage and/or contamination at intervals not to exceed three (3) months.

4. Each sealed source for which there is reason to suspect might have been damaged or might be leaking is tested for leakage and/or contamination before further use.

5. Tests for leakage and/or contamination shall be capable of detecting the presence of 0.005 microcuries (185 Bq) of radioactive material on the test sample.

6. Test samples shall be collected at the most accessible area where contamination would accumulate if the sealed source were leaking.

b. A licensee need not perform tests for leakage and/or contamination on the following 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 100 microcuries (3.7 MBq) or less of beta- and/or photon-emitting material or 10 microcuries (370 kBq) or less of alpha-emitting material;

4. Sealed sources containing only hydrogen-3;

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

RH-1212.b. (Cont'd)

6. Sealed sources, except for alpha sources, which are stored, not being used and are identified as being in storage. The licensee shall, however, test each such sealed source for leakage and/or contamination and receive the test results before any use or transfer unless it has been tested for leakage and/or contamination within the required leak test interval before the date of use or transfer. No sealed source shall be stored for a period of more than 3 years without being tested for leakage and/or contamination.

c. Tests for leakage and/or contamination, including sample collection and analysis, shall be performed by persons specifically authorized by the Department, the U.S. Nuclear Regulatory Commission, or an Agreement State to perform such services.

d. Records of test results for leakage and/or contamination shall be made in accordance with RH-1500.j.

e. Any test conducted pursuant to RH-1212. which reveals the presence of 0.005 microcuries (185 Bq) or more of removable contamination shall be considered evidence that the sealed source is leaking. The licensee shall immediately withdraw the 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 these Regulations.

f. Reports of test results indicating a leaking sealed source shall be made to the Department in accordance with RH-1508.

RH-1213. Deleted.

RH-1214. Deleted.

RH-1215. **General Provisions and Scope – Radiological Criteria for License Termination.**

a. Any person licensed to receive, possess, own, acquire, use, process, transfer, or dispose of radioactive material is subject to RH-1215. through RH-1220.

RH-1215. (Cont'd)

b. After a site has been decommissioned and the license terminated in accordance with the criteria in RH-1215. through RH-1220., the Department will require additional cleanup only if, based on new information, it determines that the criteria in RH-1215. through RH-1220. 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.

RH-1216. **Radiological Criteria for Unrestricted Use**.

A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a TEDE to an average member of the critical group that does not exceed 25 mrem (0.25 mSv) per year, including that from groundwater sources of drinking water, and the residual radioactivity has been reduced to levels that are 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.

RH-1217. **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 RH-1217 would result in net public or environmental harm or were not being made because the residual levels associated with restricted conditions are ALARA. Determination of the levels which are ALARA must take into account consideration of any detriments, such as traffic accidents, expected to potentially result from decontamination and waste disposal;

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

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

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

2. A statement of intent in the case of State or local Government licensees, as described in RH-409.h.6.D.; or

3. When a government 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 Department indicating the licensee's intent to decommission in accordance with RH-410.d. and specifying that the licensee intends to decommission by restricting use of the site. The licensee shall document in the LTP or decommissioning plan how the advice of individuals and institutions in the community who may be affected by the decommissioning has been sought and incorporated, as appropriate, following analysis of that advice.

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 25 mrem (0.25 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 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.

2. In seeking advice on the issues identified in RH-1217.d.1., the licensee shall provide for:

A. Participation by representatives of a broad cross section of community interest 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. 100 mrem (1mSv) per year; or

2. 500 mrem (1mSv) per year provided the licensee

A. Demonstrates that further reductions in residual radioactivity necessary to comply with the 100 mrem/y (1mSv/y) value of RH-1217.e.1. are not technically achievable, would be prohibitively expensive, or would result in net public or environmental harm;

B. Makes provisions for durable institutional controls; and

RH-1217.e.2. (Cont'd)

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 five (5) years to assure that the institutional controls remain in place as necessary to meet the criteria of RH-1217.b. and to assume and carry out responsibilities for any necessary control and maintenance of those controls. Acceptable financial assurance mechanisms are those in RH-1217.c.

RH-1218. **Alternate Criteria for License Termination**.

a. The Department may terminate a license using alternate criteria greater than the dose criterion of RH-1216., RH-1217.b., and RH-1217.d.1.A.i., 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 100 mrem/y (1 mSv/y) limit of Part C of Section 3, by submitting an analysis of possible sources of exposure;

2. Has employed to the extent practical restrictions on site use according to the provisions of RH-1217. 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 Department indicating the licensee's intent to decommission in accordance with RH-410.d. and specifying that the licensee proposes to decommission by use of alternate criteria. The licensee shall document in the decommissioning plan or LTP how the advice of individuals and institutions in the community who may be affected by the decommissioning has been sought and addressed, as appropriate, following analysis of that advice. In seeking such advice, the licensee shall provide for:

RH-1218.a.4. (Cont'd)

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

B. An opportunity for a comprehensive, collective discussion on the issues by the participants represented; and

C. A publicly available summary of the results of all such discussions, including a description of the individual viewpoints of the participants on the issues and the extent of agreement and disagreement among the participants on the issues.

5. Has provided sufficient financial assurance in the form of a trust fund to enable an independent third party, including a governmental custodian of a site, to assume and carry out responsibilities for any necessary control and maintenance of the site.

b. The use of alternate criteria to terminate a license requires the approval of the Department after consideration of the Department's staff recommendations that will address any comments provided by the U.S. Environmental Protection Agency, any other State Governmental organization, and any public comments submitted pursuant to RH-1219.

RH-1219. **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 RH-1217. or RH-1218., or whenever the Department deems such notice to be in the public interest, the Department shall:

a. Notify and solicit comments from:

1. Local and State government organizations in the vicinity of the site and any Indian Nation or any other indigenous people that have treaty of statutory rights that could be affected by the decommissioning; and

2. The Environmental Protection Agency (EPA) for cases where the licensee proposes to release a site pursuant to RH-1218.

RH-1219. (Cont'd)

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.

RH-1220. **Minimization of Contamination**.

a. Applicants for licenses, other than renewals, shall describe in the application how facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste.

b. Licensees shall, to the extent practical, conduct operations to minimize the introduction of residual radioactivity into the site, including the subsurface, in accordance with the existing radiation protection requirements in Part A of Section 3 and radiological criteria for license termination in RH-1215. through RH-1220.

RH-1221. Deleted. See RH-409.i.

RH-1222.- RH-1299. Reserved.

PART D.
PRECAUTIONARY PROCEDURES

RH-1300. **Surveys**.

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

1. May be necessary for the licensee or registrant to comply with the regulations in this Section; and

2. Are reasonable under the circumstances to evaluate:

A. The magnitude and extent of radiation levels,

B. Concentrations or quantities of residual radioactivity, and

C. The potential radiological hazards of the radiation levels and residual radioactivity detected.

b. Notwithstanding RH-1500.c.1., records from surveys describing the location and amount of subsurface residual radioactivity identified at the site must be kept with records important for decommissioning, and such records must be retained in accordance with RH-409.h.7., as applicable.

c. The licensee or registrant shall ensure that instruments and equipment used for quantitative radiation measurements (e.g., dose rate and effluent monitoring) are calibrated periodically for the radiation measured.

RH-1301. **Personnel Monitoring**.

a. All personnel dosimeters (except for direct and indirect reading pocket ionization chambers and those dosimeters used to measure the dose to the extremities) that require processing to determine the radiation dose and that are used by licensees or registrants to comply with RH-1302.a., with other applicable provisions of these Regulations, or with conditions specified in a license must 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 [formerly called National Bureau of Standards], and

RH-1301.a. (Cont'd)

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.

RH-1302. **Conditions Requiring Individual Monitoring of External and Internal Occupational Dose**.

Each licensee or registrant shall monitor exposures to radiation and radioactive material at levels sufficient to demonstrate compliance with the occupational dose limits of this Section. As a minimum:

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

1. Adults likely to receive, in one (1) year from sources external to the body, a dose in excess of ten percent (10%) of the limits in RH-1200.a;

2. Minors likely to receive, in one (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, from radiation sources external to the body, a deep dose equivalent in excess of 0.1 rem (1 mSv); and

NOTE: All of the occupational doses in RH-1200. continue to be applicable to the declared pregnant worker as long as the embryo/fetus dose limit is not exceeded.

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

5. Individuals working with medical fluoroscopic equipment.

A. An individual monitoring device used for the dose to an embryo/fetus of a declared pregnant woman, pursuant to RH-1207.a., shall be located under the protective apron at the waist.

RH-1302.a.5. (Cont'd)

B. An individual monitoring device used for lens dose equivalent shall be located at the neck (collar), or an unshielded location closer to the eye, outside the protective apron. If leaded eyewear is worn, the device should be clipped to the eyewear.

C. When only 1 individual monitoring device is used to determine the effective dose equivalent for external radiation, it shall be located at the neck (collar) outside the protective apron. When a second individual monitoring device is used for the same purpose, it shall be located under the protective apron at the waist. The second individual monitoring device is required for a declared pregnant woman.

b. Each licensee or registrant shall monitor, to determine compliance with RH-1203., the occupational intake of radioactive material by and assess the committed effective dose equivalent to:

1. Adults likely to receive, in one (1) year, an intake in excess of ten percent (10%) of the applicable ALI(s) in Table I, Columns 1 and 2, of Appendix G to Section 3; and

2. Minors likely to receive, in one (1) year, a committed effective dose equivalent in excess of 0.1 rem (1 mSv).

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

RH-1303. **Caution Signs, Labels, and Signals**.

a. **Symbol**.

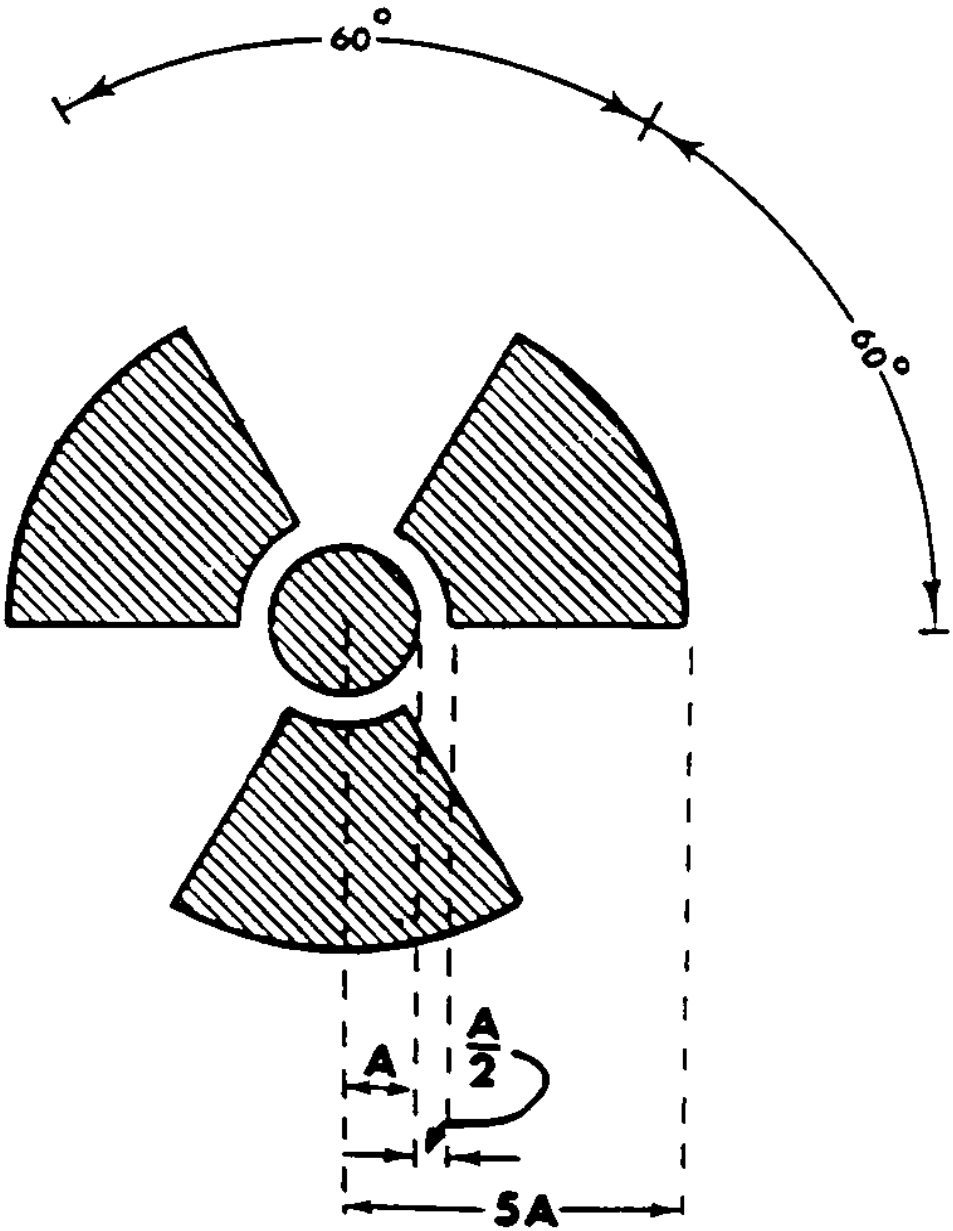
1. Except as otherwise authorized by the Department, symbols prescribed by this Section shall use the conventional radiation caution colors (magenta, or purple, or black, on yellow background).

2. The symbol prescribed by this Section is the conventional three-bladed design. The cross-hatched area shall be magenta, or purple, or black and the background yellow.

3. Notwithstanding the requirements of RH-1303.a. of this section, licensees or registrants are authorized to label sources, source holders, or device components containing sources of licensed materials that are subjected to high temperatures, with conspicuously etched or stamped radiation caution symbols and without a color requirement.

4. In addition to the contents of signs and labels prescribed in this Section, a licensee or registrant may provide on or near such signs and labels any additional information which may be appropriate in aiding individuals to minimize exposure to radiation.

RH-1303.a. (Cont'd)



RADIATION SYMBOL

RH-1303. (Cont'd)

b. **Posting requirements**.

1. **Posting of Radiation Areas.**

The licensee or registrant shall post each radiation area with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIATION AREA."

2. **Posting of High Radiation Areas.**

The licensee or registrant shall post each high radiation area with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, HIGH RADIATION AREA" or "DANGER, HIGH RADIATION AREA."

3. **Posting of Very High Radiation Areas.**

The licensee or registrant shall post each very high radiation area with a conspicuous sign or signs bearing the radiation symbol and the words "GRAVE DANGER, VERY HIGH RADIATION AREA."

4. **Posting of Airborne Radioactivity Area.**

The licensee shall post each airborne radioactivity area with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, AIRBORNE RADIOACTIVITY AREA" or "DANGER, AIRBORNE RADIOACTIVITY AREA."

5. **Posting of Areas or Rooms in which Licensed Material is Used or Stored.**

The licensee shall post each area or room in which there is used or stored an amount of licensed material exceeding ten (10) times the quantity of such material specified in Appendix H to Section 3 with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL(S)" or "DANGER, RADIOACTIVE MATERIAL(S)."

c. **High radiation areas**.

1. Deleted. See RH-1303.b.

2. The licensee or registrant shall ensure that each entrance or access point to a high radiation area has one or more of the following features:

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

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

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

3. In place of the controls required by RH-1303.c.2. of this section for a high radiation area, the licensee or registrant may substitute continuous direct or electronic surveillance that is capable of preventing unauthorized entry.

4. A licensee or registrant may apply to the Department for approval of alternative methods for controlling access to high radiation areas.

5. The licensee or registrant shall establish the controls required by RH-1303.c.2 and RH-1303.c.4 of this section in a way that does not prevent individuals from leaving a high radiation area.

6. Control is not required for 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 Department of Transportation provided that:

   A. The packages do not remain in the area longer than three (3) days; and

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

7. Control of entrance or access to rooms or other areas in hospitals is not required solely because of the presence of patients containing radioactive material, provided that there are personnel in attendance who will take the necessary precautions to prevent the exposure of individuals to radiation or radioactive material in excess of the limits established in this Section and to operate within the ALARA provisions of the licensee's radiation protection program.

d. 1. **Very high radiation areas**.

In addition to the requirements in RH-1303.c., the licensee or registrant shall institute additional measures to ensure that an individual is not able to gain unauthorized or inadvertent access to areas in which radiation levels could be encountered at 500 rads (5 grays) or more in one (1) hour at one (1) meter from a radiation source or any surface through which the radiation penetrates.

2. Deleted. See RH-1303.b.

e. **Very high radiation areas - irradiators**.

1. Each area in which there may exist radiation levels in excess of 500 rads (5 grays) in one (1) hour at one (1) meter from a sealed radioactive source[2/] that is used to irradiate materials must meet the following requirements.

A. Each entrance or access point must be equipped with entry control devices which:

i. Function automatically to prevent any individual from inadvertently entering the area when very high radiation levels exist;

ii. Permit deliberate entry into the area only after a control device is actuated that causes the radiation level within the area, from the sealed source, to be reduced below that at which it would be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in one (1) hour; and

iii. Prevent operation of the source if the source would produce radiation levels in the area that could result in a deep-dose equivalent to an individual in excess of 0.1 rem (1 mSv) in one (1) hour.

B. Additional control devices must be provided so that upon failure of the entry control devices to function as required by RH-1303.e.1.A. of this section:

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

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

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

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

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

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

E. Physical radiation barriers that comprise permanent structural components, such as walls, that have no credible probability of failure or removal in ordinary circumstances need not meet the requirements of C. and D. of this paragraph.

F. Each area must be equipped with devices that will automatically generate conspicuous visible and audible alarm signals to alert personnel in the area before the source can be put into operation and in sufficient 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 from being put into operation.

G. Each area must 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.

H. Each area must 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, the radiation level from the source in the area is below that at which it would be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in one (1) hour.

I. The entry control devices required in RH-1303.e.1.A. must be tested for proper functioning. (See RH-1500.i. for recordkeeping requirements.)

i. Testing must be conducted prior to initial operation with the source of radiation on any day (unless operations were continued uninterrupted from the previous day);

ii. Testing must be conducted prior to resumption of operation of the source of radiation after any unintended interruption; and

iii. The licensee shall submit and adhere to a schedule for periodic tests of the entry control and warning systems.

J. The licensee may not conduct operations, other than those necessary to place the source in safe condition or to effect repairs on controls, unless control devices are functioning properly.

K. Entry and exit portals that are used in transporting materials to and from the irradiation area, and that are not intended for use by individuals, must 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 processed materials must be equipped to detect and signal the presence of any loose radiation sources that are carried toward such an exit and to automatically prevent loose radiation sources from being carried out of the area.

2. Persons holding licenses or applicants for licenses for radiation sources that are within the purview of RH-1303.e.1. and that 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 RH-1303.e.1., such as those for the automatic control of radiation levels, may apply to the Radiation Control Section Chief for approval of the use of alternative safety measures. Any alternative safety measures must provide a degree of personnel protection at least equivalent to those specified in RH-1303.e.1. At least one of the alternative measures must 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 radiation sources are used.

3. The entry control devices required by RH-1303.e.1. and 2. of this section must be established in such a way that no individual will be prevented from leaving the area.

f. **Airborne radioactivity area**.

1. Deleted. Airborne radioactivity area is defined in RH-1100.

2. Deleted. See RH-1303.b.

3. **Use of process or other engineering controls**.

The licensee shall use, to the extent practical, process or other engineering controls (e.g., containment, decontamination, or ventilation) to control the concentration of radioactive material in air.

4. **Use of other controls**.

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

i. Control of access;

ii. Limitation of exposure times;

iii. Use of respiratory protection equipment; or

iv. 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.

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

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

i. The licensee shall use only respiratory protection equipment that is tested and certified or had certification extended by the National Institute for Occupational Safety and Health (NIOSH) except as otherwise noted in this Section.

ii. If the licensee wishes to use equipment that has not been tested or certified by NIOSH, or for which there is no schedule for testing or certification, the licensee shall submit an application for authorized use of this equipment, except as provided in this Section. The application must include evidence 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.

iii. The licensee 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;

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

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

(d). Written procedures regarding:

(1). Monitoring, including air sampling and bioassays;

(2). Supervision and training of respirator users;

(3). Fit testing;

(4). Respirator selection;

(5). Breathing air quality;

(6). Inventory and control;

(7). Storage, issuance, maintenance, repair, testing, and quality assurance of respiratory protection equipment;

(8). Recordkeeping; and

(9). Limitations on periods of respirator use and relief from respirator use;

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

(1). The initial fitting of a face sealing respirator;

(2). Before the first field use of a non-face sealing respirator; and

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

(f). Fit testing, with fit factor greater than or equal to 10 times the APF for negative pressure devices, and a fit factor greater than or equal to 500 for any positive pressure, continuous flow, and pressure-demand devices, before the first field use of tight fitting, face-sealing respirators and periodically thereafter at a frequency not to exceed one (1) year. Fit testing must be performed with the facepiece operating in the negative pressure mode.

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

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

vi. 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.

vii. 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 five (5) milligrams per cubic meter of air or less;

(c). Carbon monoxide (CO) content of ten (10) ppm or less;

(d). Carbon dioxide content of 1,000 ppm or less; and

(e). Lack of noticeable odor.

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

ix. 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 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 licensee shall notify, in writing, the Radiation Control Section Chief at least thirty (30) days before the date that respiratory protection equipment is first used under the provisions of RH-1303.f.5.A.

6. **Further restrictions on the use of respiratory protection equipment**.

The Department may impose restrictions in addition to those in RH-1303.f.4. and RH-1303.f.5. and Appendix E to Section 3 to:

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

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

7. **Application for use of higher assigned protection factors**.

The licensee shall obtain authorization from the Department before using assigned protection factors in excess of those specified in Appendix E to Section 3. The Department may authorize a licensee to use higher assigned 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 protection factors under the proposed conditions of use.

g. Deleted. See RH-1303.b.

h. Deleted. (See RH-1309. and RH-1310.)

i. Each licensee shall, prior to disposal of an empty uncontaminated container to unrestricted areas, remove or deface the radioactive material label or otherwise clearly indicate that the container no longer contains radioactive material.

j. All devices and equipment capable of producing radiation when operated shall be appropriately labeled so as to caution individuals that such devices or equipment produce radiation when operated.

k. Each radiation machine, except radiographic and fluoroscopic x-ray machines used solely in the healing arts, which is capable of producing, in any area accessible to individuals, a dose rate in excess of ten (10) millirems per hour shall be provided with a warning signal or light. Such a signal or light shall be so connected as to be activated automatically when the machine is "on" in order to provide adequate warning against entering the area.

RH-1304. **Exceptions From Posting Requirements**.

Notwithstanding the provisions of RH-1303.:

a. A room or area is not required to be posted with a caution sign because of the presence of a sealed source, provided the radiation level twelve (12) inches (30 centimeters) from the surface of the source container or housing does not exceed five (5) millirems (0.05 mSv) per hour.

b. Rooms or other areas in hospitals that are occupied by patients are not required to be posted with caution signs provided that the patient could be released from licensee control pursuant to RH-8420.

c. Caution signs are not required to be posted in areas or rooms containing radioactive materials for periods of less than eight (8) hours provided that:

   1. The materials are constantly attended during such periods by an individual who shall take the precautions necessary to prevent the exposure of any individual to radiation or radioactive materials in excess of the limits established in this Section; and

   2. Such area or room is subject to the licensee's control.

d. A room or other area is not required to be posted with a caution sign, and control is not required for each entrance or access point to a room or other area which is a high radiation area solely because of the presence of radioactive materials prepared for transport and packaged and labeled in accordance with regulations of the Department of Transportation.

RH-1305. **Instruction of Personnel; Posting of Notice to Employees**.

Instructions required for individuals working in or frequenting any portion of a restricted area are specified in Part N of this Section.

RH-1306. **Storage of Sources of Radiation**.

a. The licensee or registrant shall secure sources of radiation from unauthorized removal or access.

b. Sources of radiation shall not be stored in residential areas.

RH-1307. **Procedures for Picking Up, Receiving, and Opening Packages**.

a. As used in these Regulations, Special Form means any of the following physical forms of licensed material:

1. The material is in solid form having no dimension less than 0.5 millimeter or at least one dimension greater than five (5) millimeters; does not melt, sublime or ignite in air at a temperature of 1,000 ^{0}F (538 ^{0}C), will not shatter or crumble if subjected to the percussion test described in Section 4; and is not dissolved or converted into dispersible form to the extent of more than 0.005 percent by weight by immersion for one week in water at 68 ^{0}F (20 ^{0}C) or in air at 86 ^{0}F (30 ^{0}C); or

2. The material is securely contained in a capsule having no dimension less than 0.5 millimeter or at least one (1) dimension greater than five (5) millimeters, which will retain its contents if subjected to the tests prescribed in Section 4; and which is constructed of materials which do not melt, sublime or ignite in air at 1,475 ^{0}F (802 ^{0}C), and do not dissolve or convert into dispersible form to the extent of more than 0.005 percent by weight by immersion for one week in water at 68 ^{0}F (20 ^{0}C) or in air at 86 ^{0}F (30 ^{0}C).

b. Each licensee who expects to receive a package containing quantities of radioactive material in excess of a "Type A" quantity specified in or determined by procedures described in Appendix A to Section 4, shall make arrangements:

1. To receive the package when the carrier offers it for delivery; or

2. To receive notification of the arrival of the package at the carrier's terminal and to pick up the package when the carrier offers it for delivery.

c. Each licensee shall:

1. Monitor the external surfaces of a labeled[4/] package for radioactive contamination unless the package contains only radioactive material in the form of a gas or in special form as described in RH-3100.

2. Monitor the external surfaces of a labeled[4/] package for radiation levels unless the package contains quantities of radioactive material that are less than or equal to the Type A quantity as defined RH-3100 and Appendix A to Section 4; and

RH-1307.c. (Cont'd)

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.

d. The licensee shall perform the monitoring required by RH-1307.c. of this section as soon as practical after receipt of the package, but not later than three (3) hours after the package is received at the licensee's facility if it is received during the licensee's normal working hours, or not later than three (3) hours from the beginning of the next working day if it is received after working hours.

e. The licensee shall immediately notify the final delivery carrier and, by telephone and telegram, mailgram or facsimile, the Department, if packages, other than those transported by exclusive use vehicle, are found to have:

1. Removable radioactive contamination in excess of 0.001 microcurie per 100 square centimeters on the external surfaces of the package; or

2. Radiation levels at the external surface of the package in excess of 200 mRem/hr or at one (1) meter from the external surface of the package in excess of ten (10) mRem/hr.

f. Each licensee or registrant shall establish and maintain procedures for safely opening packages in which radioactive material is received and shall assure that such procedures are followed and that due consideration is given to special instructions for the type of package being opened.

g. Licensees transferring special form sources in licensee-owned or licensee-operated vehicles to and from a work site are exempt from the contamination monitoring requirements of RH-1307.c. of this section, but are not exempt from the survey requirement in RH-1307.c. of this section for measuring radiation levels that is required to ensure that the source is still properly lodged in its shield.

RH-1308. **Control of Material Not in Storage**.

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

RH-1309. **Labeling Containers**.

a. The licensee shall ensure that each container of licensed material bears a durable, clearly visible label bearing the radiation symbol and the words:

CAUTION **DANGER**

or

RADIOACTIVE MATERIAL **RADIOACTIVE MATERIAL**

The label must also provide sufficient information (such as the radionuclide(s) 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 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.

RH-1310. **Exemptions to Labeling Requirements**.

A licensee is not required to label:

a. Containers holding licensed material in quantities less than the quantities listed in Appendix H to Section 3 entitled "Quantities of Licensed Material Requiring Labeling"; or

b. Containers holding licensed material in concentrations less than those specified in Table 3 of Appendix G entitled "ALIs and DACs of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage."

c. Containers attended by an individual who takes the precautions necessary to prevent the exposure of individuals in excess of the limits established by this Section; or

d. Containers when they are in transport and packaged and labeled in accordance with the regulations of the Department of Transportation.[5/]

RH-1310. (Cont'd)

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 must 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 reactor components, piping, and tanks; or

g. Containers holding licensed material (other than sealed sources that are either specifically or generally licensed) at a facility licensed by the U.S. Nuclear Regulatory Commission (NRC) Part 50 (Domestic Licensing of Production and Utilization Facilities) or Part 52 (Licenses, Certifications, and Approvals for Nuclear Power Plants), not including non-power reactors, that are within an area posted under the requirements in RH-1303. if the containers are:

1. Conspicuously marked (such as by providing a system of color coding of containers) commensurate with the radiological hazard;

2. Accessible only to individuals who have sufficient instruction to minimize radiation exposure while handling or working in the vicinity of the containers; and

3. Subject to plant procedures to ensure they are appropriately labeled, as specified in RH-1309. before being removed from the posted area.

RH-1311. **Location of Individual Monitoring Devices**.

Each licensee or registrant shall ensure that individuals who are required to monitor occupational doses in accordance with RH-1302.a. wear individual monitoring devices as follows:

a. An individual monitoring device used for monitoring the dose to the whole body shall be worn at the unshielded location of the whole body likely to receive the highest exposure. When a protective apron is worn, the location of the individual monitoring device is typically at the neck (collar);

RH-1311. (Cont'd)

b. An individual monitoring device used for monitoring the dose to an embryo/fetus of a declared pregnant woman, pursuant to RH-1207.a., shall be located at the waist under any protective apron being worn by the woman;

c. An individual monitoring device used for monitoring the lens dose equivalent, to demonstrate compliance with RH-1200.a.2.A., shall be located at the neck (collar), outside any protective apron being worn by the monitored individual, or at an unshielded location closer to the eye. If leaded eyewear is worn, the device should be clipped to the eyewear;

d. An individual monitoring device used for monitoring the dose to the extremities, to demonstrate compliance with RH-1200.a.2.B., shall be worn on the extremity likely to receive the highest exposure. Each individual monitoring device shall be oriented to measure the highest dose to the extremity being monitored.

RH-1312.- RH-1399. Reserved.

PART E.
WASTE DISPOSAL

RH-1400. **General Requirements**.

A licensee shall dispose of licensed material only:

a. By transfer to an authorized recipient as provided in RH-1406. or in Section 2 of these Regulations, or to the Department of Energy; or

b. By decay in storage; or

c. By release in effluents within the limits in RH-1208.; or

d. As authorized under RH-1401., RH-1402., RH-1404., RH-1405., or RH-1408.

e. A person must be specifically licensed to receive waste containing licensed material from other persons for:

1. Treatment prior to disposal; or

2. Treatment or disposal by incineration; or

3. Decay in storage; or

4. Storage until transferred to a storage or disposal facility authorized to receive the waste.

RH-1401. **Method for Obtaining Approval of Proposed Disposal Procedures**.

A licensee or applicant for a license may apply to the Department for approval of proposed procedures, not otherwise authorized in these Regulations, to dispose of licensed material generated in the licensee's activities. Each application shall include:

a. A description of the waste containing licensed material to be disposed of, including the physical and chemical properties important to risk evaluation, and the proposed manner and conditions of waste disposal;

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

RH-1401. (Cont'd)

c. The nature and location of other potentially affected licensed and unlicensed facilities; and

d. Analyses and procedures to ensure that doses are maintained ALARA and within the dose limits in this Section.

RH-1402. **Disposal by Release Into Sanitary Sewerage**.

a. A licensee may discharge licensed 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;

2. The quantity of licensed or other radioactive material that the licensee releases into the sewer in one month divided by the average monthly volume of water released into the sewer by the licensee does not exceed the concentration listed in Table III of Appendix G to Section 3; and

3. If more than one (1) radionuclide is released, the following conditions must also be satisfied:

A. The licensee shall determine the fraction of the limit in Table III of Appendix G to Section 3 represented by discharges into sanitary sewerage by dividing the actual monthly average concentration of each radionuclide released by the licensee into the sewer by the concentration of that radionuclide listed in Table III of Appendix G to Section 3; and

B. The sum of the fractions for each radionuclide required by paragraph a.3.A. of this section does not exceed unity; and

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

b. Excreta from individuals undergoing medical diagnosis or therapy with radioactive material is not subject to the limitations contained in paragraph a of this section.

RH-1403. Deleted.

RH-1404. **Treatment or Disposal by Incineration**.

A licensee may treat or dispose of licensed material by incineration only in the amounts and forms specified in RH-1405. or as specifically approved by the Department pursuant to RH-1401.

RH-1405. **Disposal of Specific Wastes**.

a. Any licensee may dispose of the following licensed material without regard to its radioactivity:

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

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

b. A licensee may not dispose of tissue under paragraph a.2. of this section in a manner that would permit its use either as food for humans or as animal feed.

c. The licensee shall maintain records in accordance with RH-1500.h.

RH-1406. **Transfer for Disposal and Manifests**.

a. The requirements of this section and Appendix G to 10 CFR Part 20 are designed to:

1. Control transfers of low-level radioactive waste (LLW) by any waste generator, waste collector, or waste processor licensee, as defined in Section 2 of these Regulations, who ships low-level waste either directly, or indirectly through a waste collector or waste processor, to a licensed low-level wasteland disposal facility as defined in Section 2 of these Regulations;

2. Establish a manifest tracking system; and

3. Supplement existing requirements concerning transfers and recordkeeping for those wastes.

RH-1406. (Cont'd)

b. Any licensee shipping radioactive waste intended for ultimate disposal at a licensed land disposal facility must document the information required on the U.S. Nuclear Regulatory Commission's Uniform Low-Level Radioactive Waste Manifest and transfer this recorded manifest information to the intended consignee in accordance with Appendix G to 10 CFR Part 20.

c. Each shipment manifest must include a certification by the waste generator as specified in Section II of Appendix G to 10 CFR Part 20.

d. Each person involved in the transfer for disposal and disposal of waste, including the waste generator, waste collector, waste processor, and disposal facility operator, shall comply with the requirements specified in Section III of Appendix G to 10 CFR Part 20.

e. Any licensee shipping byproduct material as defined in paragraphs 3. and 4. of the definition of byproduct material set forth in RH-1100. intended for ultimate disposal at a land disposal facility licensed under RH-407. must document the information required on the NRC's Uniform Low-Level Radioactive Waste Manifest and transfer this recorded manifest information to the intended consignee in accordance with Appendix G to 10 CFR Part 20.

RH-1407. **Compliance with Environmental and Health Protection Regulations**.

Nothing in this Part relieves the licensee from complying with other applicable Federal, State, and local regulations governing any other toxic or hazardous properties of materials that may be disposed of under this Part.

RH-1408. **Disposal of Certain Byproduct Material**.

a. Licensed material as defined in paragraphs 3. and 4. of the definition of byproduct material set forth in RH-1100. may be disposed of in accordance with RH-407. of this chapter, even though it is not defined as low level radioactive waste. Therefore, any licensed byproduct material being disposed of at a facility, or transferred for ultimate disposal at a facility licensed under RH-407., must meet the requirements of RH-1406.

RH-1408. (Cont'd)

b. A licensee may dispose of byproduct material, as defined in paragraphs 3. and 4. of the definition of byproduct material set forth in RH-1100., at a disposal facility authorized to dispose of such material in accordance with any Federal or State solid or hazardous waste law, including the Solid Waste Disposal Act, as authorized under the Energy Policy Act of 2005.

RH-1409.- RH-1499. Reserved.

PART F.
RECORDS, REPORTS, NOTIFICATIONS, AND TESTS

RH-1500. **Records**.

a. **General provisions**.

1. Each licensee or registrant shall use the units: curie, rad, rem, including multiples and subdivisions, and shall clearly indicate the units of all quantities on records required by this Section.

2. In the records required by this Section, the licensee may record quantities in the International System of Units (SI) units in parentheses following each of the units specified in paragraph a.1. of this section. However, all quantities must be recorded as stated in paragraph a.1. of this section.

3. Notwithstanding the requirements of paragraph a.1. of this section, when recording information on shipment manifests, as required in RH-1406.b., information must be recorded in the International System of Units (SI) or in SI and units as specified in paragraph a.1. of this section.

4. The licensee or registrant shall make a clear distinction among the quantities entered on the records required by this Section (e.g., total effective dose equivalent, shallow-dose equivalent, lens dose equivalent, deep-dose equivalent, committed effective dose equivalent).

b. **Records of radiation protection programs**.

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

A. The provisions of the program; and

B. Audits and other reviews of program content and implementation.

2. The licensee or registrant shall retain the records required by paragraph b.1.A. of this section until the Department terminates each pertinent license or registration requiring the record. The licensee or registrant shall retain the records required by paragraph b.1.B. of this section for three (3) years after the record is made.

c. **Records of surveys**.

1. Each licensee or registrant shall maintain records showing the results of surveys and calibrations required by RH-1300. and RH-1307. The licensee or registrant shall retain these records for three (3) years after the record is made.

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

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

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

C. Records showing the results of air sampling, surveys, and bioassays required pursuant to RH-1303.f.5.A.iii.; and

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

d. **Determination of prior occupational dose**.

1. For each individual who is likely to receive an annual occupational dose requiring monitoring pursuant to RH-1302., the licensee or registrant shall determine the occupational radiation dose received during the current year.

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

A. The internal and external doses from all previous planned special exposures; and

B. All doses in excess of the limits (including doses received during accidents and emergencies) received during the lifetime of the individual.

3. In complying with the requirements of paragraphs d.1.and d.2. of this section, a licensee or registrant may:

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

   B. Accept, as the record of cumulative radiation dose, an up-to-date RC FORM 111, "Cumulative Occupational Dose History," or equivalent, signed by the individual and counter-signed 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); and

   C. Obtain reports of the individual's dose equivalent(s) 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, electronic media, 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.

4. The licensee or registrant shall record the exposure history, as required by paragraphs d.1. and d.2. of this section, on an up-to-date RC FORM 111, or other clear and legible record, including all of the information required on that form[6/]. The form or record must show each period in which the individual received occupational exposure to radiation or radioactive material and must be signed by the individual who received the exposure. For each period for which the licensee or registrant obtains reports, the licensee or registrant shall use the dose shown in the report in preparing RC FORM 111, 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 RC FORM 111, or equivalent, indicating the periods of time for which data are not available.

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

   A. In establishing administrative controls under RH-1200.f. for the current year, that the allowable dose limit for the individual is reduced by 1.25 rems (12.5 mSv) for each quarter for which records were unavailable and the individual was engaged in activities that could have resulted in occupational radiation exposure; and

   B. That the individual is not available for planned special exposures.

6. The licensee or registrant shall retain the records on RC FORM 111, or equivalent, until the Department terminates each pertinent license or registration requiring this record. The licensee or registrant shall retain records used in preparing RC FORM 111, or equivalent, for three (3) years after the record is made.

e. **Records of planned special exposures**.

1. For each use of the provisions of RH-1205. for planned special exposures, the licensee or registrant shall maintain records that describe:

   A. The exceptional circumstances requiring the use of a planned special exposure;

   B. The name of the management official who authorized the planned special exposure and a copy of the signed authorization;

   C. What actions were necessary;

   D. Why the actions were necessary;

   E. How doses were maintained ALARA; and

   F. What individual and collective doses were expected to result and the doses actually received in the planned special exposure.

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

f. **Records of individual monitoring results**.

1. **Recordkeeping requirement**.

Each licensee or registrant shall maintain records of doses received by all individuals for whom monitoring was required pursuant to RH-1302., and records of doses received during planned special exposures, accidents, and emergency conditions. These records[7/] must include, when applicable:

A. The deep-dose equivalent to the whole body, lens dose equivalent, shallow-dose equivalent to the skin, and shallow-dose equivalent to the extremities;

B. The estimated intake of radionuclides (See RH-1201.);

C. The committed effective dose equivalent assigned to the intake of radionuclides;

D. The specific information used to calculate the committed effective dose equivalent pursuant to RH-1203.a. and RH-1203.c. and when required by RH-1302.;

E. The total effective dose equivalent when required by RH-1201.; and

F. The total of the deep-dose equivalent and the committed dose to the organ receiving the highest total dose.

2. **Recordkeeping frequency**.

The licensee or registrant shall make entries of the records specified in paragraph f.1. of this section at least annually.

3. **Recordkeeping format**.

The licensee or registrant shall maintain the records specified in paragraph f.1. of this section on an up-to-date RC FORM 110, "Occupational Dose Record for a Monitoring Period," in accordance with the instructions for RC FORM 110, or in clear and legible records containing all the information required by that form.

4. **Privacy protection**.

The records required under this section should be protected from public disclosure because of their personal privacy nature.

5. 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.

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

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

1. Each licensee or registrant shall maintain records sufficient to demonstrate compliance with the dose limit for individual members of the public (See RH-1208.).

2. The licensee or registrant shall retain the records required by paragraph g.1. of this section until the Department terminates each pertinent license or registration requiring the record.

h. **Records of waste disposal**.

1. Each licensee shall maintain records of the disposal of licensed materials made under RH-1401., RH-1402., a previous RH-1403. that authorized certain burials[8/], RH-1404., RH-1405., and RH-1408.

2. The licensee shall retain the records required by paragraph h.1. of this section until the Department terminates each pertinent license requiring the record. Requirements for disposition of these records, prior to license termination, are located in RH-600.

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

1. Each licensee or registrant shall maintain records of tests made under RH-1303.e.1.I. on entry control devices for very high radiation areas. These records must include the date, time, and results of each such test of function.

2. The licensee or registrant shall retain the records required by paragraph i.1. of this section for three (3) years after the record is made.

j. **Records of tests for leakage and/or contamination of sealed sources.**

1. Each licensee shall maintain records of tests for leakage and/or contamination of sealed sources required by RH-1212.a. These records must include identification of the source such as manufacturer, model number, and serial number; the date the sample was collected; the date the sample was analyzed; and the measured activity of the sample in units of microcuries or becquerels.

2. The licensee shall retain the records required by paragraph j.1. of this section for three (3) years after the record is made.

k. **Records required at temporary jobsites**.

Each licensee or registrant conducting activities as described in the definition for temporary jobsite in RH-1100. shall have the following records available at the temporary jobsite for inspection by the Department:

1. Current copy of appropriate license issued by the Department, the U.S. Nuclear Regulatory Commission, or an Agreement State.

2. A copy of these Regulations.

3. Operating and Emergency Procedures.

4. The latest instrument calibration, if applicable.

5. Survey records required pursuant to RH-1803.c. for the period of operation at the jobsite, if applicable.

6. The latest leak test record for the device(s) in use at the jobsite.

7. Daily pocket dosimeter record for the period of operation at the jobsite, if applicable.

l. Reserved.

m. Reserved.

n. 1. **Record retention periods**.

A. Each licensee or registrant shall retain each record that is required by this Section or by license condition for the period specified by the appropriate regulation or license condition. If a retention period is not otherwise specified by regulation or license condition, the record must be retained until the Department terminates each license or registration that authorizes the activity that is subject to the recordkeeping requirement.

B. If there is a conflict between the Department's regulations in this Section, license condition, or other written Department approval or authorization pertaining to the retention period for the same type of record, the retention period specified in the regulations in this Section for such records shall apply unless the Department, pursuant to RH-2000., has granted a specific exemption from the record retention requirements specified in the regulations in this Section.

RH-1500.n. (Cont'd)

2. **Record maintenance**.

Each record required by this Section must be legible throughout the specified retention period. The record may 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. 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, must include all pertinent information, such as stamps, initials, and signatures. The licensee or registrant shall maintain adequate safeguards against tampering with and loss of records.

RH-1501. **Reports of Lost, Stolen, or Missing Licensed or Registered Sources of Radiation**.

a. **Telephone reports**.

1. Each licensee or registrant shall report to the Department by telephone as follows:

A. Immediately after its occurrence becomes known to the licensee, any lost, stolen, or missing licensed material in an aggregate quantity equal to or greater than 1,000 times the quantity specified in Appendix H to Section 3 under such circumstances that it appears to the licensee that an exposure could result to persons in unrestricted areas; or

B. Within 30 days after the occurrence of any lost, stolen, or missing licensed material becomes known to the licensee, all licensed material in a quantity greater than ten (10) times the quantity specified in Appendix H to Section 3 that is still missing at this time.

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

2. Reports must be made as follows:

All licensees or registrants shall make reports to the Department at 1-800-633-1735.

b. **Written reports**.

1. Each licensee or registrant required to make a report under paragraph a. of this section shall, within 30 days after making the telephone report, make a written report to the Department setting forth the following information:

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

B. A description of the circumstances under which the loss or theft occurred;

C. A statement of disposition, or probable disposition, of the licensed or registered source of radiation involved;

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

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

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

2. Reports must be made as follows:

All licensees or registrants shall make reports to the Arkansas Department of Health, Radiation Control Section Chief, 4815 West Markham Street, Slot 30, Little Rock, Arkansas, 72205-3867.

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

d. The licensee or registrant shall prepare any report filed with the Department pursuant to this section so that names of individuals who may have received exposure to radiation are stated in a separate and detachable part of the report.

RH-1502. **Notification of Incidents**.

a. **Immediate notification**.

Notwithstanding any other requirements for notification, each licensee or registrant shall immediately report to the Department any 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 25 rems (0.25 Sv) or more; or

B. A lens dose equivalent of 75 rems (0.75 Sv) or more; or

C. A shallow-dose equivalent to the skin or extremities of 250 rads (2.5 Gy) or more; or

2. The release of radioactive material, inside or outside of a restricted area, so that, had an individual been present for twenty-four (24) hours, the individual could have received an intake five (5) times the occupational annual limit on intake. (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.)

b. **Twenty-four hour notification**.

Each licensee or registrant shall, within twenty-four (24) hours of discovery of the event, report to the Department any 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 twenty-four (24) hours:

A. A total effective dose equivalent exceeding five (5) rems (0.05 Sv); or

B. A lens dose equivalent exceeding fifteen (15) rems (0.15 Sv); or

C. A shallow-dose equivalent to the skin or extremities exceeding fifty (50) rems (0.5 Sv); or

RH-1502.b. (Cont'd)

2. The release of radioactive material, inside or outside of a restricted area, so that, had an individual been present for twenty-four (24) hours, the individual could have received an intake in excess of one occupational annual limit on intake. (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. Licensees or registrants shall make the reports required by this section by telephone to the Department at 1-800-633-1735 and by confirming letter to the Arkansas Department of Health, Radiation Control Section Chief, 4815 West Markham Street, Slot 30, Little Rock, Arkansas, 72205-3867.

d. The licensee or registrant shall prepare any report filed with the Department pursuant to this section so that names of individuals who have received exposure to sources of radiation are stated in a separate and detachable part of the report.

e. The provisions of this section do not include doses that result from planned special exposures, provided such doses are within the limits for planned special exposures and are reported under RH-1503.

RH-1503. **Reports of Planned Special Exposures.**

The licensee or registrant shall submit a written report to the Department within thirty (30) days following any planned special exposure conducted in accordance with RH-1205., informing the Department that a planned special exposure was conducted and indicating the date the planned special exposure occurred and the information required by RH-1500.e.

RH-1504. **Reports of Exposures, Radiation Levels, and Concentrations of Radioactive Material Exceeding the Constraints or Limits**.

a. **Reportable events**.

In addition to the notification required by RH-1502., each licensee or registrant shall submit a written report within thirty (30) days after learning of any of the following occurrences:

1. Any incident for which notification is required by RH-1502.; or

2. Doses in excess of any of the following:

   A. The occupational dose limits for adults in RH-1200.; or

   B. The occupational dose limits for a minor in RH-1206.; or

   C. The limits for an embryo/fetus of a declared pregnant woman in RH-1207.; or

   D. The limits for an individual member of the public in RH-1208.; or

   E. Any applicable limit in the license; or

   F. The ALARA constraints for air emissions established under RH-1004.d.; or

3. Levels of radiation or concentrations of radioactive material in:

   A. A restricted area in excess of any applicable limit in the license; or

   B. An unrestricted area in excess of ten (10) times any applicable limit set forth in this Section or in the license (whether or not involving exposure of any individual in excess of the limits in RH-1208.); or

4. For licensees subject to the provisions of EPA's generally applicable environmental radiation standards in 40 CFR Part 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 paragraph a. of this section must describe the extent of exposure of individuals to radiation and radioactive material, including, as appropriate:

   A. Estimates of each individual's dose;

   B. The levels of radiation and concentrations of radioactive material involved;

C. The cause of the elevated exposures, dose rates, or concentrations; and

D. Corrective steps taken or planned to ensure against a recurrence, including the schedule for achieving conformance with applicable limits, ALARA constraints, generally applicable environmental standards, and associated license conditions.

2. Each report filed pursuant to paragraph a. of this section must include for each occupationally overexposed[9/] individual: the name, social security number, or other unique identifier, and date of birth. The report must be prepared so that this information is stated in a separate and detachable part of the report.

3. The licensee or registrant shall prepare any report filed with the Department pursuant to this section so that names of individuals who have received exposure to sources of radiation are stated in a separate and detachable part of the report.

c. Licensees or registrants who make reports pursuant to paragraph a. of this section shall submit the report in writing to the Arkansas Department of Health, Radiation Control Section Chief, 4815 West Markham Street, Slot 30, Little Rock, Arkansas, 72205-3867.

RH-1505. **Notifications and Reports to Individuals**.

a. Requirements for notification and reports to individuals of exposure to radiation or radioactive material are specified in Part N of this Section (RH-2804).

a. **Reports to individuals of exceeding dose limits**.

When a licensee or registrant is required pursuant to RH-1503. or RH-1504. to report to the Department any exposure of an identified occupationally exposed individual, or an identified member of the public, to radiation or radioactive material, the licensee or registrant shall also provide the individual a report on his or her exposure data included in the report to the Department. The report must be transmitted no later than the transmittal to the Department.

RH-1506. **Notification of Intent to Vacate Premises.**

Each specific licensee shall, no less than thirty (30) days before vacating or relinquishing possession or control of premises which may have been contaminated with radioactive material as a result of the activities, notify the Department in writing of intent to vacate. When deemed necessary by the Department, the licensee shall decontaminate the premises in such a manner as the Department may specify.

RH-1507. Deleted. Refer to RH-8703. and RH-8800.

RH-1508. **Reports of Leaking Sealed Sources.**

A licensee shall file a report with the Department within five (5) days if a test for leakage and/or contamination required by RH-1212. reveals the presence of 0.005 microcuries (185 Bq) or more of removable contamination. The written report must include the results of the test; the date the test results were received; identification of the source such as manufacturer, model number, and serial number; the radionuclide and its estimated activity; any equipment involved; any contamination which resulted from the leaking source; and the corrective actions taken.

RH-1509. **Reports of Individual Monitoring**.

a. This section applies to each person licensed by the Department to:

1. Possess or use radioactive material for purposes of radiography pursuant to Part I of Section 3; or

RH-1509.a. (Cont'd)

2. Possess or use at any time, for processing or manufacturing for distribution pursuant to Section 2 or 9 of these Regulations, radioactive material in quantities exceeding any one of the following quantities:

TABLE TO RH-1509.a.2.

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

[a] The Department may require as a license condition, or by rule, Regulation, or order pursuant to RH-2001., reports from licensees who are licensed to use radionuclides not on this list, in quantities sufficient to cause comparable radiation levels.

b. Each licensee in a category listed in paragraph a. of this section shall complete an annual report of the results of individual monitoring carried out by the licensee for each individual for whom monitoring was required by RH-1302. during that year. The licensee may include additional data for individuals for whom monitoring was provided but not required. The licensee shall use an up-to-date RC FORM 110 or equivalent containing all the information required by RC FORM 110.

c. The licensee shall complete the report required by paragraph b. of this section, covering the preceding year, on or before May 31 of each year. The licensee shall retain the report and submit it, if requested, to the Arkansas Department of Health, Radiation Control Section Chief, 4815 West Markham Street, Slot 30, Little Rock, Arkansas, 72205-3867.

RH-1510. Deleted. Refer to RH-8308., RH-8703., and RH-8800.

RH-1511. Deleted. Refer to RH-107.

RH-1512. Deleted. Refer to RH-1500.k.

RH-1513. **Reports of Transactions Involving Nationally Tracked Sources**.

Each licensee who manufactures, transfers, receives, disassembles, or disposes of a nationally tracked source shall complete and submit a National Source Tracking Transaction Report as specified in paragraphs a. through e. of this section for each type of transaction. See Appendix D to Section 3, "Nationally Tracked Source Thresholds."

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

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

2. The name of the individual preparing the report;

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

4. The radioactive material in the source;

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

6. The manufacture date of the source.

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

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

2. The name of the individual preparing the report;

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

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

5. The radioactive material in the source;

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

7. The date for which the source strength is reported;

8. The shipping date;

9. The estimated arrival date; and

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

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

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

2. The name of the individual preparing the report;

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

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

5. The radioactive material in the source;

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

7. The date for which the source strength is reported;

8. The date of receipt; and

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

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

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

2. The name of the individual preparing the report;

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

4. The radioactive material in the source;

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

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

7. The disassemble date of the source.

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

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

2. The name of the individual preparing the report;

3. The waste manifest number;

4. The container identification with the nationally tracked source;

5. The date of disposal; and

6. The method of disposal.

f. The reports discussed in paragraphs a. through e. of this section must be submitted by the close of the next business day after the transaction. A single report may be submitted for multiple sources and transactions. The reports must be submitted to the National Source Tracking System by using:

1. The on-line National Source Tracking System;

2. Electronically using a computer-readable format;

3. By facsimile;

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

5. By telephone with follow-up by facsimile or mail.

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

h. Each licensee that possesses Category 1 nationally tracked sources shall report its initial inventory of Category 1 nationally tracked sources to the National Source Tracking System by January 31, 2009. Each licensee that possesses Category 2 nationally tracked sources shall report its initial inventory of Category 2 nationally tracked sources to the National Source Tracking System by January 31, 2009. The information may be submitted by using any of the methods identified by paragraph f.1. through f.4. of this section. The initial inventory report must include the following information:

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

2. The name of the individual preparing the report;

3. The manufacturer, model, and serial number of each nationally tracked source or, if not available, other information to uniquely identify the source;

4. The radioactive material in the sealed source;

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

6. The date for which the source strength is reported.

RH-1514.- RH-1519. Reserved.

RH-1520. **Tests**.

Upon instruction from the Department, each licensee and registrant shall perform or cause to have performed, and shall permit the Department to perform, such reasonable tests as the Department deems appropriate or necessary, including, but not limited to, tests of:

a. Sources of radiation;

b. Facilities wherein sources of radiation are used or stored;

c. Radiation detection and monitoring instruments; and

d. Other equipment and devices used in connection with utilization or storage of licensed or registered sources of radiation.

RH-1521.- RH-1599. Reserved.

PART G.
SPECIAL REQUIREMENTS FOR THE USE OF X-RAYS IN THE HEALING ARTS

RH-1600. **Scope**.

This Part establishes requirements, for which a registrant (or licensee) is responsible, for use of x-ray equipment by or under the supervision of an individual authorized by and licensed in accordance with state statutes to engage in the healing arts or veterinary medicine. The provisions of this Part are in addition to and not in substitution for, other applicable provisions of these Regulations.

RH-1601. **Definitions**.

Accessible surface - The external surface of the enclosure or housing provided by the manufacturer.

Added filtration - Any filtration which is in addition to the inherent filtration

Aluminum equivalent - The thickness of type 1100 aluminum alloy[11/] affording the same attenuation, under specified conditions, as the material in question.

Assembler - Any person engaged in the business of assembling, replacing or installing one or more components into an x-ray system or subsystem.

Attenuation block - A block or stack, having dimensions 20 centimeters by 20 centimeters by 3.8 centimeters, of type 1100 aluminum alloy[11/] or other materials having equivalent attenuation.

Automatic exposure control - A device which automatically controls one or more technique factors in order to obtain at a pre-selected location(s) a required quantity of radiation. (See also "Phototimer.")

Barrier - See "Protective barrier."

Beam axis - A line from the source through the centers of the x-ray fields.

Beam-limiting device - A device which provides a means to restrict the dimensions of the x-ray field.

Beam monitoring system - A system designed to detect and measure the radiation present in the useful beam.

Calibration - The determination of (1) the response or reading of an instrument relative to a series of known radiation values over the range of the instrument or (2) the strength of a source of radiation relative to a standard.

Cephalometric device - A device intended for the radiographic visualization and measurement of the dimensions of the human head.

Certified components - Components of x-ray systems which are subject to regulations promulgated under Public Law 90-602, the Radiation Control for Health and Safety Act of 1968.

Certified system - Any x-ray system which has one or more certified component(s).

Changeable filters - Any filter, exclusive of inherent filtration, which can be removed from the useful beam through any electronic, mechanical or physical process.

Coefficient of variation or "C" - The ratio of the standard deviation to the mean value of a population of observations. It is estimated using the following equation:

$$C = \frac{s}{\bar{x}} = \frac{1}{\bar{x}}\left[\sum_{i=1}^{n}\frac{\left(x_i - \bar{x}\right)^2}{n-1}\right]^{\frac{1}{2}}$$

where:

s = Estimated standard deviation of the population;

$\bar{x}$ = Mean value of observations in sample;

x_i = i^{th} observation in sample; and

n = Number of observations in sample.

Contact therapy system - An x-ray system used for therapy with the x-ray tube port placed in contact with or within five (5) centimeters of the surface being treated.

Control panel - That part of the x-ray control upon which are mounted the switches, knobs, push buttons, and other hardware necessary for manually setting the technique factors.

Cooling curve - The graphical relationship between heat units stored and cooling time.

Dead-man switch - A switch constructed that a circuit closing contact can be maintained only by continuous pressure on the switch by the operator.

Detector - See "Radiation detector."

Diagnostic source assembly - The tube housing assembly with a beam-limiting device attached.

Diagnostic x-ray system - An x-ray system designed for irradiation of any part of the human body for the purpose of diagnosis or visualization.

Direct scattered radiation - The scattered radiation which has been deviated in direction only by materials irradiated by the useful beam. (See "Scattered radiation.")

Entrance exposure - The roentgens per unit time at the point where the center of the useful beam enters the patient.

Equipment - See "X-ray equipment."

Exposure - The quotient of dQ by dm where dQ is the absolute value of the total charge of the ions of one sign produced in air when all the electrons (negatrons and positrons) liberated by photons in a volume element of air having mass dm are completely stopped in air. (The special unit of exposure is the roentgen [R]).

Field emission equipment - Equipment which uses an x-ray tube in which electron emission from the cathode is due solely to the action of an electric field.

Filter - Material placed in the useful beam to absorb preferentially selected radiations.

Fluoroscopic imaging assembly - A subsystem in which x-ray photons produce a fluoroscopic image. It includes the image receptor(s) such as the image intensifier and spot-film device, electrical interlocks, if any, and structural material providing linkage between the image receptor and diagnostic source assembly.

Focal spot - The area projected on the anode of the x-ray tube by the electrons accelerated from the cathode and from which the useful beam originates.

Full beam detector - A radiation detector of such size that the total cross section of the maximum size useful beam is intercepted.

General purpose radiographic x-ray system - Any radiographic x-ray system which, by design, is not limited to radiographic examination of specific anatomical regions.

Gonad shield - A protective barrier for the testes or ovaries.

Half-value layer - The thickness of specified material which attenuates the beam of radiation to an extent such that the exposure rate is reduced to one-half of its original value. In this definition, the contribution of all scattered radiation, other than any which might be present initially in the beam concerned, is deemed to be excluded.

Healing arts screening - The testing of human beings using x-ray machines for the detection or evaluation of health indications when such tests are not specifically and individually ordered by a licensed practitioner of the healing arts legally authorized to prescribe such x-ray tests for the purpose of diagnosis or treatment.

Heat unit - A unit of energy equal to the product of the peak kilovoltage, milliamperes and seconds, i.e., kVp x mA x second.

HVL - See "Half-value layer."

Image intensifier - A device, installed in its housing, which instantaneously converts an x-ray pattern into a corresponding light image of higher energy density.

Image receptor - Any device, such as a fluorescent screen or radiographic film, which transforms incident x-ray photons either into a visible image or into another form which can be made into a visible image by further transformations.

Image receptor support - For mammographic systems, that part of the system designed to support the image receptor in a horizontal plane during a mammographic examination.

Inherent filtration - The filtration of the useful beam provided by the permanently installed components of the tube housing assembly.

Interlock - A device arranged or connected such that the occurrence of an event or condition is required before a second event or condition can occur or continue to occur.

Irradiation - The exposure of matter to ionizing radiation.

Kilovolts peak - See "Peak tube potential."

kV - Kilovolts.

kVp - See "Peak tube potential."

kWs - Kilowatt second. It is equivalent to 10^3 kV·mA·sec, i.e.,

$$(A)\text{kWs} = (X)\text{kV} \cdot (Y)\text{mA} \cdot (Z)\text{sec} \cdot \frac{\text{kWs}}{10^3\text{kV} \cdot \text{mA} \cdot \text{sec}} = \frac{\text{XYZ kWs}}{10^3}$$

Lead equivalent - The thickness of lead affording the same attenuation, under specified conditions, as the material in question.

Leakage radiation - Radiation emanating from the diagnostic or therapeutic source assembly except for:

1. the useful beam, and

2. radiation produced when the exposure switch or timer is not activated.

Leakage technique factors - The technique factors associated with the tube housing assembly which are used in measuring leakage radiation. They are defined as follows:

1. For capacitor energy storage equipment, the maximum-rated peak tube potential and the maximum-rated number of exposures in an hour for operation at the maximum-rated peak tube potential with the quantity of charge per exposure being 10 millicoulombs, i.e., 10 milliampere seconds or the minimum obtainable from the unit, whichever is larger.

2. For field emission equipment rated for pulsed operation, the maximum-rated peak tube potential and the maximum-rated number of x-ray pulses in an hour for operation at the maximum-rated peak tube potential.

3. For all other equipment, the maximum-rated peak tube potential and the maximum-rated continuous tube current for the maximum-rated peak tube potential.

Light field - That area of the intersection of the light beam from the beam-limiting device and one of the set of planes parallel to and including the plane of the image receptor, whose perimeter is the focus of points at which the illumination is one-fourth of the maximum in the intersection.

Line-voltage regulation - The difference between the no-load and the load line potentials expressed as a percentage of the load line potential. It is calculated using the following equation:

Percent line-voltage regulation = $100(V_n-V_1)/V_1$

where:

V_n = No-load line potential; and
V_1 = Load line potential.

mA - Milliampere.

mAs - Milliampere second.

Maximum line current - The root-mean-square current in the supply line of an x-ray machine operating at its maximum rating.

Mobile equipment - See "X-ray equipment."

Patient - An individual subjected to healing arts examination, diagnosis or treatment.

Peak tube potential - The maximum value of the potential difference across the x-ray tube during an exposure.

Phantom - A volume of material behaving in a manner similar to tissue with respect to the attenuation and scattering of radiation.

Phototimer - A method for controlling radiation exposures to image receptors by the amount of radiation which reaches a radiation monitoring device(s). The radiation monitoring device(s) is part of an electronic circuit which controls the duration of time the tube is activated. (See "Automatic exposure control.")

PID - See "Position indicating device."

Position indicating device - A device on dental x-ray equipment used to indicate the beam position and to establish a definite source-surface (skin) distance. It may or may not incorporate or serve as a beam-limiting device.

Primary dose monitoring system - A system which will monitor the useful beam during irradiation and which will terminate irradiation when the pre-selected number of dose monitor units have been acquired.

Primary protective barrier - See "Protective barrier."

Protective apron - An apron made of radiation attenuating materials used to reduce radiation exposure.

Protective barrier - A barrier of radiation attenuating material(s) used to reduce radiation exposure. The types of protective barriers are as follows:

1. Primary protective barrier - The material, excluding filters, placed in the useful beam, for protection purposes, to reduce the radiation exposure.

2. Secondary protective barrier - A barrier sufficient to attenuate the stray radiation to the required degree.

Protective glove - A glove made of radiation attenuating materials used to reduce radiation exposure.

Qualified expert - An individual who has demonstrated to the satisfaction of the Department that such individual possesses the knowledge and training to measure ionizing radiation, to evaluate safety techniques and to advise regarding radiation protection needs.

Radiation detector - A device which in the presence of radiation provides by either direct or indirect means, a signal or other indication suitable for use in measuring one or more quantities of incident radiation.

Radiation therapy simulation system - A radiographic or fluoroscopic x-ray system intended for localizing the volume to be exposed during radiation therapy and confirming the position and size of the therapeutic irradiation field.

Radiograph - An image receptor on which the image is created directly or indirectly by an x-ray pattern and results in a permanent record.

Radiograph imaging system - Any system whereby a permanent or semi-permanent image is recorded on an image receptor by the action of ionizing radiation.

Rating - The operating limits as specified by the component manufacturer.

Recording - Producing a permanent form of an image resulting from x-ray photons (e.g., film, video tape).

Response time - The time required for an instrument system to reach 90 percent (90%) of its final reading when the radiation-sensitive volume of the instrument system is exposed to a step change in radiation flux from zero sufficient to provide a steady state mid scale reading.

Scattered radiation - Radiation that, during passage through matter, has been deviated in direction. (See "Direct scattered radiation.")

Secondary dose monitoring system - A system which will terminate irradiation in the event of failure of the primary system.

Secondary protective barrier - See "Protective barrier."

Shutter - A device attached to the tube housing assembly which can totally intercept the useful beam and which as a lead equivalency not less than that of the tube housing assembly.

SID - See "Source-image receptor distance."

Source - The focal spot of the x-ray tube.

Source-image receptor distance - The distance from the source to the center of the input surface of the image receptor.

Spot check - A procedure which is performed to assure that a previous calibration continues to be valid.

Spot film - A radiograph which is made during a fluoroscopic examination to permanently record conditions which exist during that fluoroscopic procedure.

Spot-film device - A device intended to transport and/or position a radiographic image receptor between the x-ray source and fluoroscopic image receptor. It includes a device intended to hold a cassette over the input end of an image intensifier for the purpose of making a radiograph.

SSD - The distance between the source and the skin of the patient.

Stationary equipment - See "X-ray equipment."

Stray radiation - The sum of leakage and scattered radiation.

Technique factors - The conditions of operation. They are specified as follows:

1. For capacitor energy storage equipment, peak tube potential in kV and quantity of charge in mAs.

2. For field emission equipment rated for pulsed operation, peak tube potential in kV and number of x-ray pulses.

3. For all other equipment, peak tube potential in kV and either tube current in mA and exposure time in seconds or the product of tube current and exposure time in mAs.

Termination of irradiation - The stopping of irradiation in a fashion which will not permit continuance of irradiation without the resetting of operating conditions at the control panel.

Traceable to a national standard - A quantity or a measurement that has been compared to a NIST* (National Institute of Standards and Technology) standard directly or indirectly through one or more intermediate steps and that all comparisons have been documented.

Therapeutic-type housing -

1. For x-ray therapy equipment not capable of operating at 500 kVp or above, the following definition applies: An x-ray tube housing so constructed that the leakage radiation averaged over any 100 cm^2 area at a distance of one meter from the source does not exceed one roentgen in an hour when the tube is operated at its maximum rated continuous current for the maximum rated tube potential.

2. For x-ray therapy equipment capable of operation at 500 kVp or above, the following definition applies: An x-ray tube housing so constructed that leakage radiation averaged over any 100 cm^2 area at a distance of one meter from the source does not exceed 0.1 percent of the useful beam dose rate at one meter from the source for any of its operating conditions.

Therapeutic x-ray and/or electron system - A system designed for irradiation of any part of the human body for the purpose of treatment or alleviation of symptoms of disease.

Tube - An x-ray tube, unless otherwise specified.

*formerly NBS (National Bureau of Standards)

Tube housing assembly - The tube housing with tube installed. It includes high-voltage and/or filament transformers and other appropriate elements when such are contained within the tube housing.

Tube rating chart - The set of curves which specify the rated limits of operation of the tube in terms of the technique factors.

Useful beam - The radiation which passes through the tube housing port and the aperture of the beam-limiting device when the exposure switch or timer is activated.

Variable-aperture beam-limiting device - A beam-limiting device which has capacity for stepless adjustment of the x-ray field size at a given SID.

Visible area - That portion of the input surface of the image receptor over which incident x-ray photons are producing a visible image.

Wedge filter - An added filter effecting continuous progressive attenuation on all or part of the useful beam.

X-ray control - A device which controls input power to the x-ray high-voltage generator and/or the x-ray tube. It includes equipment such as timers, phototimers, automatic brightness stabilizers and similar devices, which control the technique factors of an x-ray exposure.

X-ray equipment - An x-ray system, subsystem or component thereof. Types of x-ray equipment are as follows:

1. Mobile x-ray equipment: X-ray equipment mounted on a permanent base with wheels and/or casters for moving while completely assembled.

2. Portable x-ray equipment: X-ray equipment designed to be hand-carried.

3. Stationary x-ray equipment: X-ray equipment which is installed in a fixed location.

X-ray field - The area of the intersection of the useful beam and any one of the set of planes parallel to and including the plane of the image receptor, whose perimeter is the locus of points at which the exposure rate is one-fourth of the maximum in the intersection.

RH-1601. (Cont'd)

X-ray high-voltage generator - A device which transforms electrical energy from the potential supplied by the x-ray control to the tube operating potential. The device may also include means for transforming alternating current to direct current, filament transformers for the x-ray tube(s), high-voltage switches, electrical protective devices and other appropriate elements.

X-ray system - An assemblage of components for the controlled production of x-rays. It includes an x-ray high-voltage generator, an x-ray control, a tube housing assembly, a beam-limiting device and the necessary supporting structures. Additional components which function with the system are considered integral parts of the system.

X-ray subsystem - Any combination of two or more components of an x-ray system.

X-ray tube - Any electron tube which is designed to be used primarily for the production of x-rays.

RH-1602. **General Requirements**. **Administrative Controls**.

a. **Registrant**.

The registrant shall be responsible for directing the operation of the x-ray systems which have been registered with the Department. The registrant or the registrant's agent shall assure that the requirements of RH-1602.a. are met in the operation of the x-ray system(s).

1. An x-ray system which does not meet the provisions of these Regulations shall not be operated for diagnostic or therapeutic purposes.

2. Individuals who will be operating the x-ray systems shall be adequately instructed in the safe operating procedures and be competent in the safe use of the equipment.

3. A chart shall be provided in the vicinity of the diagnostic x-ray system's control panel which specifies, for all examinations performed with that system, the following information:

A. Patient's anatomical size versus technique factors to be utilized;

B. Type and size of the film or film-screen combination to be used;

C. Type and focal distance of the grid to be used, if any;

D. Source to image receptor distance to be used; and

E. Type and location of placement of gonad shielding to be used.

F. For mammography, indication of kVp/target/filter combination.

4. Written safety procedures and rules shall be provided to each individual operating x-ray equipment, including any restrictions of the operating technique required for the safe operation of the particular x-ray system. The operator shall be able to demonstrate familiarity with these rules.

5. Except for patients who cannot be moved out of the room, only the staff and ancillary personnel required for the medical procedure or training shall be in the room during the radiographic exposure. Other than the patient being examined:

A. All individuals shall be positioned such that no part of the body will be struck by the useful beam unless protected by 0.5 millimeter lead equivalent.

B. Staff and ancillary personnel shall be protected from the direct scatter radiation by protective aprons or whole body protective barriers of not less than 0.25 millimeter lead equivalent.

C. Patients who cannot be removed from the room shall be protected from the direct scatter radiation by whole body protective barriers of 0.25 millimeter lead equivalent or shall be so positioned that the nearest portion of the body is at least two meters from both the tube head and the nearest edge of the image receptor.

6. New gonad shielding of not less than 0.5 millimeter lead equivalent material shall be used for human patients, who have not passed the reproductive age, during radiographic procedures in which the gonads are in the useful beam, except for cases in which this would interfere with the diagnostic procedure.

7. Individuals shall not be exposed to the useful beam except for healing arts purposes and such exposure has been authorized by a licensed practitioner of the healing arts. This provision specifically prohibits deliberate exposure for the following purposes:

   A. Exposure of an individual for training, demonstration or other non-healing-arts purposes; and

   B. Exposure of an individual for the purpose of healing arts screening except as authorized by RH-1602.a.11.

8. When a patient or film must be provided with auxiliary support during a radiation exposure:

   A. Mechanical holding devices shall be used when the technique permits.

   B. If a human holder must be utilized:

      i. Written safety procedures, as required by RH-1602.a.4., shall indicate the requirements for selecting a holder and the procedure the holder shall follow;

      ii. The human holder shall be protected as required by RH-1602.a.5.;

      iii. No individual shall be used routinely to hold film or patients;

      iv. Such holding shall be permitted only in very unusual and rare situations;

v. In those cases where the patient must hold the film, except during intra-oral examinations, any portion of the body, other than the area of clinical interest, struck by the useful beam shall be protected by not less than 0.5 millimeter lead equivalent material; and

vi. Each facility shall have leaded aprons and gloves available in sufficient numbers to provide protection to all personnel who are involved with x-ray operations and who are otherwise not shielded.

9. Procedures and auxiliary equipment designed to minimize patient and personnel exposure commensurate with the needed diagnostic information shall be utilized. This is interpreted to include but not limited to:

A. The speed of film or screen and film combinations shall be the fastest speed consistent with the diagnostic objective of the examinations.

B. The radiation exposure to the patient shall be the minimum exposure required to produce images of good diagnostic quality.

C. Portable or mobile equipment shall be used only for examinations where it is impractical to transfer the patient(s) to a stationary radiographic installation.

D. X-ray systems subject to RH-1604. shall not be utilized in procedures where the source to patient distance is less than thirty (30) centimeters.

i. X-ray systems shall not be utilized in procedures where the source to patient distance is less than thirty (30) centimeters, except for veterinary systems.

ii. If grids are used between the patient and the image receptor to decrease scatter to the film and improve contrast, the grid shall:

(a) Be positioned properly, i.e., tube side facing the right direction, and grid centered to the central ray;

(b). If of the focused type, be of the proper focal distance for the SIDs being used.

10. All individuals who are associated with the operation of an x-ray system are subject to the requirements of RH-1200.

A. When protective clothing or devices are worn on portions of the body and a monitoring device(s) is required, at least one such monitoring device shall be utilized as follows:

i. When an apron is worn, the monitoring device shall be worn at the collar outside of the apron.

ii. The dose to the whole body based on the maximum dose attributed to the most critical organ shall be recorded in the reports required by Part F to Section 3 of these Regulations. If more than one device is used and a record is made of the data, each dose shall be identified with the area where the device was worn on the body.

B. Exposure of a personnel monitoring device to deceptively indicate a dose delivered to an individual is prohibited.

11. **Healing arts screening**.

Any person proposing to conduct a healing arts screening program shall not initiate such a program without prior approval of the Department. When requesting such approval, that person shall submit the information as deemed necessary by the Department. If any information submitted to the Department becomes invalid or out-dated, the Department will be notified in writing within thirty (30) days.

12. **Information and maintenance record and associated information**.

The registrant shall maintain the following information for each x-ray system for inspection by the Department:

A. Maximum rating of technique factors;

B. Model and serial numbers of all certifiable components;

C. Aluminum equivalent filtration of the useful beam, including any routine variation;

D. Tube rating charts and cooling curves;

E. Records of surveys, calibrations, maintenance and modifications performed on the X-ray system(s) after July 1, 1983 with the names of persons who performed such services;

F. A scale drawing of the room in which a stationary x-ray system is located with such drawing indicating the use of areas adjacent to the room and an estimation of the extent of occupancy by an individual in such areas. In addition, the drawing shall include:

i. The results of a survey for radiation levels present at the operator's position and at pertinent points outside the room at specified test conditions; or

ii. The type and thickness of materials or lead equivalency, of each protective barrier; and

G. A copy of all correspondence with the Department regarding that x-ray system.

13. **X-ray log**.

Each facility shall maintain an x-ray log containing the patient I.D., the type of examinations and the dates the examinations were performed. When the patient or film must be provided with human auxiliary support, the name of the human holder shall be recorded.

b. **General requirements for all diagnostic x-ray systems**.

In addition to other requirements of this Part, all diagnostic x-ray systems shall meet the following requirements:

1. **Warning label**.

The control panel containing the main power switch shall bear the warning statement or its equivalent, legible and accessible to view: "WARNING: This x-ray unit may be dangerous to patient and operator unless safe exposure factors and operating instructions are observed."

2. **Battery charge indicator**.

On battery-powered x-ray generators, visual means shall be provided on the control panel to indicate whether the battery is in a state of charge adequate for proper operation.

3. **Leakage radiation from the diagnostic source assembly**.

The leakage radiation from the diagnostic source assembly measured at a distance of one (1) meter in any direction from the source shall not exceed 100 milliroentgens in one (1) hour when the x-ray tube is operated at its leakage technique factors. Compliance shall be determined by measurements averaged over an area of 100 square centimeters with no linear dimension greater than 20 centimeters.

4. **Radiation from components other than the diagnostic source assembly**.

The radiation emitted by a component other than the diagnostic source assembly shall not exceed two (2) milliroentgens in one (1) hour at five (5) centimeters from any accessible surface of the component when it is operated in an assembled x-ray system under any conditions for which it was designed. Compliance shall be determined by measurements averaged over an area of 100 square centimeters with no linear dimension greater than twenty (20) centimeters.

5. **Beam quality**.

A. **Half-value layer**.

i. The half-value layer of the useful beam for a given x-ray tube potential shall not be less than the values shown in Table I to RH-1602. If it is necessary to determine such half-value layer at an x-ray tube potential which is not listed in Table I, linear interpolation or extrapolation may be made.

TABLE I TO RH-1602.

Design Operating Range (Kilovolts peak)	Measured Potential (Kilovolts peak)	Half-value Layer (millimeters of aluminum)
----Below 50----	30	0.3
	40	0.4
	49	0.5
----50 to 70----	50	1.2
	60	1.3
	70	1.5
----Above 70----	71	2.1
	80	2.3
	90	2.5
	100	2.7
	110	3.0
	120	3.2
	130	3.5
	140	3.8
	150	4.1

ii. The requirements of RH-1602.b.5.A.i. will be considered to have been met if it can be demonstrated that the aluminum equivalent of the total filtration in the primary beam is not less than that shown in Table II to RH-1602.

TABLE II TO RH-1602.

Filtration Required vs. Operating Voltage	
Operating Voltage (kVp)	**Total Filtration (inherent plus added) (millimeters aluminum equivalent)**
Below 50	0.5
50 to 70	1.5
Above 70	2.5

iii. Beryllium window tubes shall have a minimum of 0.5 millimeter aluminum equivalent filtration permanently installed in the useful beam.

iv. For capacitor energy storage equipment, compliance with the requirements of RH-1602.b.5. shall be determined with the maximum quantity of charge per exposure.

v. The required minimal aluminum equivalent filtration shall include the filtration contributed by all materials which are always present between the source and the patient.

B. **Filtration controls**.

For x-ray systems which have variable kVp and variable filtration for the useful beam, a device shall link the kVp selector with the filter(s) and shall prevent an exposure unless the minimum amount of filtration required by RH-1602.b.5.A.i. or ii. is in the useful beam for the given kVp which has been selected.

6. **Multiple tubes**.

Where two or more radiographic tubes are controlled by one exposure switch, the tube or tubes which have been selected shall be clearly indicated prior to initiation of the exposure. This indication shall be both on the x-ray control panel and at or near the tube housing assembly which has been selected.

7. **Mechanical support of tube head**.

The tube housing assembly supports shall be adjusted such that the tube housing assembly will remain stable during an exposure unless tube housing movement is a designed function of the x-ray system.

c. **Other requirements**.

1. Pass boxes, if provided, shall be so constructed as to exclude light from the darkroom when cassettes are placed in or removed from boxes, and shall incorporate adequate shielding from stray radiation to prevent exposure of undeveloped film.

2. The darkroom shall be light tight and use proper safelighting such that any film type in use exposed in a cassette to x-radiation sufficient to produce an optical density for one (1) to two (2) when processed shall not suffer an increase in density greater than 0.1 (0.05 mammography) when exposed in the darkroom for two (2) minutes with all safelights on. If used, daylight film handling boxes shall preclude fogging of the film.

3. Darkrooms typically used by more than one individual shall be provided a method to prevent accidental entry while undeveloped films are being handled or processed.

4. Film shall be stored in a cool, dry place and shall be protected from exposure to stray radiation. Film in open packages shall be stored in a light tight container.

5. Film cassettes and intensifying screens shall be inspected periodically and shall be cleaned and replaced as necessary to best assure radiographs of good diagnostic quality.

6. Outdated x-ray film shall not be used for diagnostic radiographs, unless the film has been stored in accordance with manufacturer's recommendations and a sample of the film passes a sensitometric test for normal ranges of base plus fog and speed.

7. Film developing solutions shall be prepared in accordance with the directions given by the manufacturer, and shall be maintained in strength by replenishment or renewal so that full development is accomplished within the time specified by the manufacturer.

A. The technique factors to be used during an exposure shall be indicated before the exposure begins. If automatic exposure controls are used, the technique factors which are set prior to the exposure shall be indicated. The requirement may be permanent markings on equipment having fixed technique factors. Indication of technique factors shall be visible from the operator's position except in the case of spot films made by the fluoroscopist.

B. The requirement may be permanent markings on equipment having fixed technique factors. Indication of technique factors shall be visible from the operator's position except in the case of spot films made by the fluoroscopist.

8. **Maintaining Compliance**.

Diagnostic x-ray systems and their associated components used on humans and certified pursuant to the Federal X-Ray Equipment Performance Standard (21 CFR Part 1020) shall be maintained in compliance with applicable requirements of that standard.

9. **Locks**.

All position locking, holding, and centering devices on x-ray system components and systems shall function as intended.

RH-1603. **Fluoroscopic X-Ray Systems**.

All fluoroscopic x-ray systems shall meet the following requirements:

a. **Limitation of useful beam**.

1. **Primary barrier**.

A. The fluoroscopic imaging assembly shall be provided with a primary protective barrier which intercepts the entire cross section of the useful beam at any Source Image Distance (SID).

A. The x-ray tube used for fluoroscopy shall not produce x-rays unless the barrier is in position to intercept the entire useful beam.

2. **Fluoroscopic beam limitation**.

A. For certified fluoroscopic systems with or without a spot film device, neither the length nor the width of the x-ray field in the plane of the image receptor shall exceed that of the visible area of the image receptor by more than three percent (3%) of the SID. The sum of the excess length and the excess width shall be no greater than four percent (4%) of the SID.

B. For uncertified fluoroscopic systems with a spot film device, the x-ray beam with the shutter fully opened (during fluoroscopy or spot filming) shall be no larger than the largest spot film size for which the device is designed. Measurements shall be made at the maximum SID available but at no less than twenty (20) centimeters from the tabletop to the film plane distance.

C. For uncertified fluoroscopic systems without a spot film device, the requirements of RH-1603. apply.

D. **Other requirements for fluoroscopic beam limitation**:

i. Means shall be provided to permit further limitation of the field. Beam-limiting devices manufactured after May 22, 1979, and incorporated in equipment with a variable SID or a visible area of greater than 300 square centimeters shall be provided with means for stepless adjustment of the x-ray field;

ii. All equipment with a fixed SID and a visible area of 300 square centimeters or less shall be provided either with stepless adjustment of the x-ray field or with means to further limit the x-ray field size at the plane of the image receptor to 125 square centimeters or less;

iii. If provided, stepless adjustment shall, at the greatest SID, provide continuous field sizes from the maximum attainable to a field size of five (5) centimeters by five (5) centimeters or less;

iv. For equipment manufactured after February 25, 1978, when the angle between the image receptor and beam axis is variable, means shall be provided to indicate when the axis of the x-ray beam is perpendicular to the plane of the image receptor;

v. For noncircular x-ray fields used with circular image receptors, the error in alignment shall be determined along the length and width dimensions of the x-ray field which pass through the center of the visible area of the image receptor.

3. **Spot-film beam limitation**.

Spot-film devices shall meet the following requirements:

A. Means shall be provided between the source and the patient for adjustment of the x-ray field size in the plane of the film to the size of that portion of the film which has been selected on the spot film automatically accomplished except when the x-ray field size in the plane of the film is smaller than that of the selected portion of the film. For spot-film devices manufactured after June 21, 1979, if the x-ray field size is less than the size of the selected portion of the film, the means for adjustment of the field size shall be only at the operator's option;

B. Neither the length nor the width of the x-ray field in the plane of the image receptor shall differ from the corresponding dimensions of the selected portion of the image receptor by more than three percent (3%) of the SID when adjusted for full coverage of the selected portion of the image receptor. The sum, without regard to sign, of the length and width differences shall not exceed four percent (4%) of the SID;

C. It shall be possible to adjust the x-ray field size in the plane of the film to a size smaller than the selected portion of the film. The minimum field size at the greatest SID shall be equal to, or less than, five (5) centimeters by five (5) centimeters;

D. The center of the x-ray field in the plane of the film shall be aligned with the center of the selected portion of the film to within two percent (2%) of the SID; and

E. On spot-film devices manufactured after February 25, 1978, if the angle between the plane of the image receptor and beam axis is variable, means shall be provided to indicate when the axis of the x-ray beam is perpendicular to the plane of the image receptor, and compliance shall be determined with the beam axis indicated to be perpendicular to the plane of the image receptor.

4. **Override**.

If a means exists to override any of the automatic x-ray field size adjustments required, that means:

A. Shall be designed for use only in the event of system failure;

B. Shall incorporate a signal visible at the fluoroscopist's position which will indicate whenever the automatic field size adjustment is overridden; and

C. Shall have a clear and durable label as follows:

i. For x-ray fields.

ii. Limitation system failure.

iii. Activation of the fluoroscopic tube.

iv. X-ray production in the fluoroscopic mode shall be controlled by a device which requires continuous pressure by the fluoroscopist for the entire time of any exposure. When recording serial fluoroscopic images, the fluoroscopist shall be able to terminate the x-ray exposure(s) at any time, but means may be provided to permit completion of any single exposure of the series in process.

b. **Exposure rate limits**.

1. **Entrance exposure rate allowable limits**.

A. Fluoroscopic equipment that is provided with automatic exposure rate control shall not be operable at any combination of tube potential and current which will result in an exposure rate in excess of ten (10) roentgens (2.6 mC/kg) per minute at the point where the center of the useful beam enters the patient, except:

i. During recording of fluoroscopic images; or

ii. When an optional high level control is provided. When so provided, the equipment shall not be operable at any combination of tube potential and current which will result in an exposure rate in excess of five (5) roentgens (1.3 mC/kg) per minute at the point where the center of the useful beam enters the patient unless the high level control is activated. Special means of activation of high level controls shall be required. The high level control shall only be operable when continuous manual activation is provided by the operator. A continuous signal audible to the fluoroscopist shall indicate that the high level control is being employed.

B. Fluoroscopic equipment which is not provided with automatic exposure rate control shall not be operable at any combination of tube potential and current which will result in an exposure rate in excess of five (5) roentgens (1.3 mC/kg) per minute at the point where the center of the useful beam enters the patient, except:

i. During recording of fluoroscopic images; or

ii. When the mode or modes have an optional high level control, in which case the mode or modes shall not be operable at any combination of tube potential and current which shall result in an exposure rate in excess of 5 roentgens (1.3 mC/kg) per minute at the point where the center of the useful beam enters the patient, unless the high level control is activated. Special means of activation of high level controls shall be required. The high level control shall only be operable when continuous manual activation is provided by the operator. A continuous signal audible to the fluoroscopist shall indicate that the high level control is being employed.

C. Compliance with the requirements of RH-1603. shall be determined as follows:

i. Movable grids and compression devices shall be removed from the useful beam during the measurement;

ii. If the source is below the table, exposure rate shall be measured one (1) centimeter above the table top or cradle;

iii. If the source is above the table, the exposure rate shall be measured at 30 centimeters above the tabletop with the end of the beam-limiting device or spacer positioned as closely as possible to the point of measurement;

iv. All C-arm fluoroscopes, both stationary and mobile, shall meet the entrance exposure rate limits at 30 centimeters from the input surface of the fluoroscopic imaging assembly with the source positioned at any available SID provided that the end of the spacer assembly or beam-limiting device is not closer than 30 centimeters from the input surface of the fluoroscopic imaging assembly.

v. For a lateral type fluoroscope, the exposure rate shall be measured at a point 15 centimeters from the centerline of the x-ray table and in the direction of the x-ray source with the end of the beam limiting device or spacer positioned as closely as possible to the point of measurement. If the tabletop is movable, it shall be positioned as closely as possible to the lateral x-ray source, with the end of the beam-limiting device or spacer no closer than 15 centimeters to the centerline of the x-ray table.

D. Fluoroscopic equipment which is provided with both automatic exposure rate control mode and a manual mode shall not be operable at any combination of tube potential and current which shall result in an exposure rate in excess of ten (10) roentgens (2.6 mC/kg) per minute in either mode at the point where the center of the useful beam enters the patient, except:

i. During recording of fluoroscopic images; or

ii. When the mode or modes have an optional high-level control, in which case the mode or modes shall not be operable at any combination of tube potential and current which shall result in an exposure rate in excess of five (5) roentgens (1.3 mC/kg) per minute at the point where the center of the useful beam enters the patient, unless the high level control is activated. Special means of activation of high level controls shall be required. The high level control shall only be operable when continuous manual activation is provided by the operator. A continuous signal audible to the fluoroscopist shall indicate that the high level control is being employed.

E. Any fluoroscopic equipment manufactured after May 19, 1995, which can exceed five (5) roentgens (1.3 mC/kg) per minute shall be equipped with an automatic exposure rate control. All entrance exposure rate limits shall be ten (10) roentgens (2.6 mC/kg) per minute with an upper limit of 20 roentgens (5.2 mC/kg) per minute when the high level control is activated.

F. Conditions of periodic measurement of maximum entrance exposure rate are as follows:

i. The measurement shall be made under the conditions that satisfy the requirements;

ii. The kVp, mA, or other selectable parameters shall be adjusted to those settings which give the maximum entrance exposure rate;

iii. The x-ray system(s) that incorporates automatic exposure rate control shall have sufficient attenuative material placed in the useful beam to produce either a milliamperage or kilovoltage or both to satisfy the conditions of RH-1603.

c. **Barrier transmitted radiation rate limits**.

1. The exposure rate due to transmission through the primary protective barrier with the attenuation block in the useful beam, combined with radiation from the image intensifier, if provided, shall not exceed two (2) milliroentgens (0.516 μC/kg) per hour at ten (10) centimeters from any accessible surface of the fluoroscopic imaging assembly beyond the plane of the image receptor for each roentgen per minute of entrance exposure rate.

2. **Measuring compliance of barrier transmission**.

A. The exposure rate due to transmission through the primary protective barrier combined with radiation from the image intensifier shall be determined by measurements averaged over an area of 100 square centimeters with no linear dimension greater than 20 centimeters.

B. If the source is below the tabletop, the measurement shall be made with the input surface of the fluoroscopic imaging assembly positioned 30 centimeters above the tabletop.

C. If the source is above the tabletop and the SID is variable, the measurement shall be made with the end of the beam-limiting device or spacer as close to the tabletop as it can be placed, provided that it shall not be closer than 30 centimeters.

D. Movable grids and compression devices shall be removed from the useful beam during the measurement.

3. **Indication of potential and current**.

During fluoroscopy and cinefluorography, the kV and the mA shall be continuously indicated.

d. **Source-to-skin distance**.

The SSD shall not be less than:

1. 38 centimeters on stationary fluoroscopes installed on or after August 1, 1974;

2. 35.5 centimeters on stationary fluoroscopes which were in operation prior to August 1, 1974; 30 centimeters on all mobile fluoroscopes;

3. 20 centimeters for mobile fluoroscopes used for specific surgical application;

4. The written safety procedures must provide precautionary measures to be adhered to during the use of this device in addition to the procedures provided in RH-1603.

e. **Fluoroscopic timer**.

1. Means shall be provided to preset the cumulative on-time of the fluoroscopic x-ray tube. The maximum cumulative time of the timing device shall not exceed five (5) minutes without resetting.

2. A signal audible to the fluoroscopist shall indicate the completion of any preset cumulative on-time. Such signal shall continue to sound while x-rays are produced until the timing device is reset.

f. **Control of scattered radiation**.

1. Fluoroscopic table designs when combined with procedures utilized shall be such that no unprotected part of any staff or ancillary individual's body shall be exposed to un-attenuated scattered radiation which originates from under the table. The attenuation required shall be not less than 0.25 millimeter lead equivalent.

2. Equipment configuration when combined with procedures shall be such that no portion of any staff or ancillary individual's body, except the extremities, shall be exposed to the un-attenuated scattered radiation emanating from above the tabletop unless that individual:

A. Is at least 120 centimeters from the center of the useful beam, or

B. The radiation has passed through not less than 0.25 millimeter lead equivalent material including, but not limited to, drapes, Bucky-slot cover panel, or self-supporting curtains, in addition to any lead equivalency provided by the protective apron referred to in RH-1603.

3. The Department may grant exemptions where a sterile field will not permit the use of the normal protective barriers. Where the use of prefitted sterilized covers for the barriers is practical, the Department shall not permit such exemption.

g. **Spot-film exposure reproducibility**.

Fluoroscopic systems equipped with spot-film (radiographic) mode shall meet the exposure reproducibility requirements when operating in the spot-film mode.

1. Radiation therapy simulation systems shall be exempt from all the requirements provided that:

A. Such systems are designed and used in such a manner that no individual other than the patient is in the x-ray room during periods of time when the system is producing x-rays; and

B. Systems which do not meet the requirements are provided with a means of indicating the cumulative time that an individual patient has been exposed to x-rays. Procedures shall require in such cases that the timer be reset between examinations.

h. **Special procedures estimated patient exposure documentation**.

1. Each facility using fluoroscopic equipment for procedures including, but not limited to:

A. Pacemaker implantation;

B. Diagnostic cardiac procedures (catheterization); and

C. Therapeutic cardiac procedures:

i. Angioplasty-balloon;

ii. Stent;

iii. Directional coronary atherectomy;

D. Radio frequency ablation;

E. Intravascular brachytherapy;

F. All neurointerventional procedures including:

i. Embolizations;

ii. Interventional radiology procedures such as:

(a). TIPS;

(b). Vascular embolizations;

(c). Stents; and

(d). Angioplasty;

G. Infusion drug procedures:

i. Complex biliary cases;

ii. Complex gastrointestinal cases; and

iii. Complex genitourinary procedures.

shall include in a log for Department review the estimated patient radiation exposure received per procedure. Estimated adult skin doses that exceed 300 rad and estimated skin doses for children (under the age of 18) that exceed 100 rad must be reviewed by the facility's radiation safety committee.

The review must document the reason why an estimated skin dose exceeded 300 rad for adults or 100 rad for children, and the reason must be documented in the committee's minutes. If a facility does not have a radiation safety committee, the facility must provide the Department, within thirty (30) days of the event, documentation stating why the patient's estimated dose exceeded 300 rad for adults or 100 rad for children.

i. **Equipment operation**.

1. All imaging formed by the use of fluoroscopic x-ray systems shall be directly viewed and interpreted by a licensed practitioner of the healing arts.

2. Overhead fluoroscopy shall not be used as a positioning tool for general purpose radiographic examinations.

3. Facilities that use fluoroscopic x-ray systems shall maintain a record of cumulative fluoroscopic exposure time used and the number of spot films for each examination. This record shall indicate patient identification, type of examination, date of examination, and operator's name.

j. **Periodic measurements**.

1. Periodic measurement of entrance exposure rate shall be performed by a qualified expert for both typical and maximum values as follows:

A. Such measurements shall be made annually or after any maintenance of the system which might affect the exposure rate.

B. Results of these measurements shall be available where any fluoroscopist may have ready access to such results while using the fluoroscope. The measurement results shall be stated in coulombs per kilogram or mR/hr and include the technique factors used in measurements. The date the measurements were performed shall also be included in the results.

C. Conditions of periodic measurement of typical entrance exposure rate are as follows:

i. The measurement shall be made under the conditions that satisfy the requirements;

ii. The kVp, mA, and/or other selectable parameters shall be adjusted to those settings typical of clinical use on a 23 cm thick abdominal patient;

iii. The x-ray system that incorporates automatic exposure rate control shall have sufficient attenuative material placed in the useful beam to produce a milliamperage and/or kilovoltage to satisfy the conditions.

D. Conditions of periodic measurement of maximum entrance exposure rate are as follows:

i. The measurements shall be made under the conditions that satisfy the requirements;

ii. The kVp, mA and/or other selectable parameters shall be adjusted to those settings which give the maximum entrance exposure rate;

iii. The x-ray system(s) that incorporates automatic exposure rate control shall have sufficient attenuative material placed in the useful beam to produce the maximum entrance exposure rate of the system.

RH-1604. **Radiographic Systems Other than Fluoroscopic, Dental Intraoral, Veterinarian, or Computed Tomography Systems**.

a. **Beam limitation**.

1. The useful beam shall be limited to the area of clinical interest. This shall be considered met if a positive beam-limiting device meeting manufacturer's specifications has been properly used or if evidence of collimation is shown on at least three sides or three corners of the film (for example, projections from the shutters of the collimator, cone cutting at the corners, or borders at the film's edge.)

2. **General purpose stationary and mobile x-ray systems and veterinarian systems (other than portable) installed after July 1, 1998**.

A. Only x-ray systems provided with means for independent stepless adjustment of at least two (2) dimensions of the x-ray field shall be used.

B. A method shall be provided for visually defining the perimeter of the x-ray field.

i. Illuminance shall be greater than 7.5 foot-candles or 80.3 LUX at 100 centimeters or maximum SID whichever is less.

ii. The total misalignment of the edges of the visually defined field with the respective edges of the x-ray field along either the length or width of the visually defined field shall not exceed two percent (2%) of the distance from the source to the center of the visually defined field when the surface upon which it appears is perpendicular to the axis of the x-ray beam.

iii. The Department may grant an exemption on non-certified x-ray provided the registrant makes a written application for such exemption and in that application demonstrates it is impractical to comply and the purpose will be met by other methods.

3. **Additional requirements for stationary general purpose x-ray systems**.

In addition to the requirements for stationary general purpose x-ray systems, both certified and non-certified systems shall also meet the following requirements:

A. Method shall be provided to indicate when the axis of the x-ray beam is perpendicular to the plane of the image receptor, to align the center of the x-ray field with respect to the center of the image receptor to within two percent (2%) of the SID, and to indicate the SID to within two percent (2%);

B. The beam-limiting device shall indicate numerically the field size in the plane of the image receptor to which it is adjusted; and

C. Indication of field size dimensions and SIDs shall be specified in inches or centimeters, and shall be such that aperture adjustments result in x-ray field dimensions in the plane of the image receptor which correspond to those indicated by the beam-limiting device to within two percent (2%) of the SID when the beam axis is indicated to be perpendicular to the plane of the image receptor.

4. Reserved.

5. **X-ray systems designed for one (1) image receptor size**.

Radiographic equipment designed for only one (1) image receptor size at a fixed SID shall be provided with means to limit the field at the plane of the image receptor to dimensions no greater than those of the image receptor, and to align the center of the x-ray field with the center of the image receptor to within two percent (2%) of the SID, or shall be provided with means to both size and align the x-ray field such that the x-ray field at the plane of the image receptor does not extend beyond any edge of the image receptor.

6. **Other x-ray systems and veterinary systems installed prior to July 1, 1998, and all portable veterinary x-ray systems**.

A. Means shall be provided to limit the x-ray field in the plane of the image receptor so that such field does not exceed each dimension of the image receptor by more than two percent (2%) of the SID when the axis of the x-ray beam is perpendicular to the plane of the image receptor.

B. Means shall be provided to align the center of the x-ray field with the center of the image receptor to within two percent (2%) of the SID, or means shall be provided to both size and align the x-ray field such that the x-ray field at the plane of the image receptor does not extend beyond any edge of the image receptor. Compliance shall be determined with the axis of the x-ray beam perpendicular to the plane of the image receptor.

C. Alignment requirements may be met with either:

i. An assortment of removable, fixed-aperture, beam-limiting devices sufficient to meet the requirement for each combination of image receptor size and SID for which the unit is designed with each such device having clear and permanent markings to indicate the image receptor size and SID for which it is designed; or

ii. A beam-limiting device having multiple fixed apertures sufficient to meet the requirement for each combination of image receptor size and SID for which the unit is designed. Permanent, clearly legible markings shall indicate the image receptor size and SID for which each aperture is designed and shall indicate which aperture is in position for use.

b. **Radiation exposure control devices**.

1. **Timers**.

A. Means shall be provided to initiate the radiation exposure by a deliberate action on the part of the operator, such as the depression of a switch. Radiation exposure shall not be initiated without such an action.

B. Means shall be provided to terminate the exposure at a preset time interval, preset product of current and time, a preset number of pulses, or a preset radiation exposure to the image receptor. In addition, it shall not be possible to make an exposure when the timer is set to a "**zero**" or "**off**" position if either position is provided. Except for dental panoramic systems, termination of an exposure shall cause automatic resetting of the timer to its initial setting or to "**zero**."

2. **X-ray control**. **Manual exposure control**.

A. An x-ray control shall be incorporated into each x-ray system such that an exposure can be terminated by the operator at any time except for exposure of one-half second or less, or during serial radiography when means shall be provided to permit completion of any single exposure of the series in process.

B. Each x-ray control shall be located in such a way as to meet the following requirements:

i. Stationary x-ray systems (except dental, podiatry and veterinary units) shall be required to have the x-ray exposure switch permanently mounted in a protected area so that the operator is required to remain in that protected area during the entire exposure and so that the operator can view the patient while making any exposures;

ii. Mobile and portable x-ray systems which are:

(a.) Used for greater than one (1) week in the same location, i.e., a room or suite; or

(b). Used for greater than one (1) hour and less than one (1) week at the same location, i.e., a room or suite; or

(c). In a clinical setting for routine extremities only, or where moving the x-ray system from room to room is impractical;

(d). Shall meet the requirement of the above paragraph RH-1604.b.2.B.i., or one of the following must be met.

(1). Equipment installed or relocated after January 1, 2006 is placed at least nine (9) feet (2.7 meters) from the tube housing assembly.

(2). Equipment installed before January 1, 2006 is placed at least six (6) feet (1.8 meters) from the tube housing assembly.

C. Written procedures must instruct the operator to remain in the protected area during the entire exposure.

iii. (a). Stationary podiatric systems installed or relocated after January 1, 2006, which do not meet the above requirements, shall be provided with a nine (9) foot exposure button cord which allows the operator to remain behind a protective barrier during the entire exposure.

(b). Stationary podiatric systems installed before January 1, 2006, which do not meet the above requirements, shall be provided with a six (6) foot exposure button which allows the operator to remain behind a protective barrier during the entire exposure.

(c). If the protective barrier is moveable, written procedures must be on-file at the facility, which dictate that the operator will remain behind the barrier during the entire exposure.

C. The x-ray control shall provide visual indication observable at or from the operator's protected position whenever x-rays are produced. In addition, a signal audible to the operator shall indicate that the exposure has terminated.

3. **Automatic exposure controls**.

When an automatic exposure control is provided:

A. Indication shall be made on the control panel when this mode of operation is selected;

B. If the x-ray tube potential is equal to or greater than 50 kVp, the minimum exposure time for field emission equipment rated for pulsed operation shall be equal to or less than a time interval equivalent to two (2) pulses;

C. The minimum exposure time for all equipment shall be equal to or less than one-sixtieth second or a time interval required to deliver five (5) mAs, whichever is greater;

D. Either the product of peak x-ray tube potential, current, and exposure time shall be limited to not more than 60 kWs per exposure, or the product of x-ray tube current and exposure time shall be limited to not more than 600 mAs per exposure except that, when the x-ray tube potential is less than 50 kVp, the product of x-ray tube current and exposure time shall be limited to not more than 2000 mAs per exposure; and

E. A visible signal shall indicate when an exposure has been terminated, and manual resetting shall be required before further automatically timed exposures can be made.

4. **Reproducibility**.

With a timer setting of 0.5 seconds or less, the average exposure period (T) shall be greater than or equal to five (5) times the maximum exposure period (T_{max}) minus the minimum exposure period (T_{min}) when four timer tests are performed:

$$T > 5\ (T_{max} - T_{min})$$

5. **Exposure duration (timer) linearity**.

For systems having independent selection of exposure time settings, the average ratios (X_1) of exposure to the indicated timer setting, in units of C $kg^{-1}s^{-1}$ (mR/s), obtained at any two clinically used timer settings shall not differ by more than 0.10 times their sum. This is written as:

$$(X_1 - X_2) < 0.1\ (X_1 + X_2)$$

where X_1 and X_2 are the average C $kg^{-1}s^{-1}$ (mR/s) values.

c. **Source-to-skin distance**.

All mobile or portable radiographic systems shall be provided with means to limit the source-to-skin distance to equal to or greater than thirty (30) centimeters except for veterinary systems.

d. **Exposure reproducibility**.

When all technique factors are held constant, including control panel selections associated with automatic exposure control systems, the coefficient of variation of exposure for both manual and automatic exposure control systems shall not exceed 0.05. This requirement applies to clinically used techniques.

e. **Radiation from capacitor energy storage equipment in standby status**.

Radiation emitted from the x-ray tube when the system is fully charged and the exposure switch or timer is not activated shall not exceed a rate of two (2) milliroentgens (0.516 μC/kg) per hour at five (5) centimeters from any accessible surface of the diagnostic source assembly, with the beam-limiting device fully open.

f. **Accuracy**.

Deviation of measured technique factors from indicated values of kVp and exposure time shall not exceed the limits specified for that system by its manufacturer. In the absence of manufacturer's specifications, the deviation shall not exceed ten percent (10%) of the indicated value for kVp and twenty percent (20%) for time mA/mAs linearity.

g. The following requirements apply when the equipment is operated on a power supply as specified by the manufacturer for any fixed x-ray tube potential within the range of forty percent (40%) to one hundred percent (100%) of the maximum rated:

1. **Equipment having independent selection of x-ray tube current (mA)**.

The average ratios (X_1) of exposure to the indicated milliampere-seconds product (C $kg^{-1}mAs^{-1}$ (or mR/mAs)) obtained at any two (2) consecutive tube current settings shall not differ by more than 0.10 times their sum:

$$X_1 - X_2 < 0.10 (X_1 + X_2)$$

where X_1 and X_2 are the average values obtained at each of two (2) consecutive tube current settings, or at two settings differing by no more than a factor of two (2) where the tube current selection is continuous.

2. **Equipment having a combined x-ray tube current-exposure time product (mAs) selector, but not a separate tube current (mA) selector**.

The average ratios (X_1) of exposure to the indicated milliampere-seconds product, in units of mR/mAs (or C $kg^{-1}mAs^{-1}$), obtained at any two consecutive mAs selector settings shall not differ by more than 0.10 times their sum:

$$X_1 - X_2 < 0.10 (X_1 + X_2)$$

where X_1 and X_2 are the average values obtained at any two (2) consecutive mAs selector settings, or at two (2) settings differing by no more than a factor of two (2) where the mAs selector provides continuous selection.

3. **Measuring compliance**.

Determination of compliance shall be based on ten (10) exposures taken within a time period of one (1) hour, at each of the two (2) settings. These two (2) settings may include any two focal spot sizes except where one is equal to or less than 0.45 millimeters and the other is greater than 0.45 millimeters. For purposes of this requirement, focal spot size is the nominal focal spot size specified by the x-ray tube manufacturer.

h. **Additional requirements applicable to certified systems only**.

Diagnostic x-ray systems incorporating one or more certified component(s) shall be required to comply with the following additional requirement(s) which relate to that certified component(s).

i. **Beam limitation for stationary and mobile general purpose x-ray systems**.

1. There shall be provided a means of stepless adjustment of the x-ray field. The minimum field size at an SID of 100 centimeters shall be equal to or less than five (5) centimeters by five (5) centimeters.

2. When a light localizer is used to define the x-ray field, it shall provide an average illumination of not less than 160 lux or 15 foot-candles at 100 centimeters or at the maximum SID, whichever is less. The average illumination shall be based upon measurements made in the approximate center of each quadrant of the light field. Radiation therapy simulation systems manufactured on and after May 27, 1980, are exempt from this requirement.

3. The edge of the light field at 100 centimeters or at the maximum SID, whichever is less, shall have a contrast ratio, corrected for ambient lighting, of not less than four (4) in the case of beam-limiting devices designed for use on stationary equipment, and a contrast ratio of not less than three (3) in the case of beam-limiting devices designed for use on mobile equipment. The contrast ratio is defined as I_1/I_2 where I_1 is the illumination three (3) millimeters from the edge of the light field toward the center of the field; and I_2 is the illumination three (3) millimeters from the edge of the light field away from the center of the field.

4. Compliance shall be determined with a measuring instrument aperture of one (1) millimeter in diameter.

j. **Beam limitation and alignment on stationary general purpose x-ray systems equipped with Positive Beam Limitation (PBL)**.

If PBL is being used, the following requirements shall be met:

1. PBL shall prevent the production of x-rays when:

A. Either the length or width of the x-ray field in the plane of the image receptor differs from the corresponding image receptor dimensions by more than three percent (3%) of the SID; or

B. The sum of the length and width differences, without regard to sign exceeds four percent (4%) of the SID;

C. Compliance shall be determined when the equipment indicates that the beam axis is perpendicular to the plane of the image receptor. Compliance shall be determined no sooner than five (5) seconds after insertion of the image receptor;

RH-1604.j.1. (Cont'd)

D. The PBL system shall be capable of operation, at the discretion of the operator, such that the size of the field may be made smaller than the size of the image receptor through stepless adjustment of the field size. The minimum field size at an SID of 100 centimeters shall be equal to or less than five (5) centimeters by five (5) centimeters;

E. The PBL system shall be designed such that if a change in image receptor does not cause an automatic return to PBL function, then any change of image receptor size or SID must cause the automatic return.

2. **Beam limitation for portable x-ray systems**.

Beam limitation for portable x-ray systems shall meet the beam limitation requirements.

3. **Tube stands for portable x-ray systems**.

A tube stand or other mechanical support shall be used for portable x-ray systems, so that the x-ray tube housing assembly need not be handheld during exposures.

k. Systems used in a clinical (non-surgical) setting shall be restricted to one room within a location or suite which meets the requirements.

RH-1605. Reserved.

RH-1606. **Intraoral Dental Radiographic Systems**.

The requirements for general x-ray tubes apply to the intraoral dental machines.

a. **Source-to-skin distance**.

X-ray systems designed for use with an intraoral image receptor shall be provided with means to limit source-to-skin distance to not less than:

1. 18 centimeters if operable above 50 kVp, or

2. 10 centimeters if not operable above 50 kVp.

b. **Beam limitation**.

Radiographic systems designed for use with an intraoral image receptor shall be provided with means to limit the X-ray beam such that:

1. If the minimum source-to-skin distance (SSD) is 18 centimeters or more, the x-ray field, at the minimum SSD, shall be containable in a circle having a diameter of no more than seven (7) centimeters; and

2. If the minimum SSD is less than 18 centimeters, the x-ray field, at the minimum SSD, shall be containable in a circle having a diameter of no more than six (6) centimeters.

3. The position indicating device shall be shielded and open-ended. The shielding shall be equivalent to the requirements.

c. **Exposure control**. **Exposure initiation**.

A. Means shall be provided to initiate the radiation exposure by deliberate action on the part of the operator, such as the depression of a switch. Radiation exposure shall not be initiated without such an action; and

B. It shall not be possible to make an exposure when the timer is set to a "**zero**" or "**off**" position if either position is provided.

d. **Exposure indication**.

Means shall be provided for visual indication observable at or from the operator's protected position whenever x-rays are produced. In addition, a signal audible to the operator shall indicate that the exposure has terminated except in x-ray systems that cannot be altered to meet this requirement.

e. **Exposure termination**.

1. Means shall be provided to terminate the exposure at a preset time interval, preset product of current and time, a preset number of pulses, or a preset radiation exposure to the image receptor. In addition:

A. Termination of exposure shall cause automatic resetting of the timer to its initial setting or to "**zero**."

B. An x-ray control shall be incorporated into each x-ray system such that an exposure can be terminated by the operator at any time, except for exposures of one-half (½) second or less.

2. **Exposure duration (timer) linearity**.

For systems having independent selection of exposure time settings, the average ratios (X_1) of exposure to the indicated timer setting, in units of C $kg^{-1}s^{-1}$ (mR/s), obtained at any two clinically used timer settings shall not differ by more than 0.10 times their sum. This is written as:

$$(X_1 - X_2) < 0.1 (X_1 + X_2)$$

where X_1 and X_2 are the average values.

3. Each x-ray exposure switch shall be located in such a way as to meet the following requirements:

A. Stationary x-ray systems shall be required to have the x-ray exposure switch located in a protected area or have an exposure switch cord of sufficient length to permit the operator to activate the unit while in a protected area, e.g., corridor outside the operatory. The procedures must instruct the operator to remain in the protected area during the entire exposure.

B. Mobile and portable x-ray systems which are:

i. Used for greater than one (1) week in the same location, i.e., a room or suite, shall meet the other requirements.

ii. Used for greater than one (1) hour and less than one (1) week at the same location, i.e., a room or suite, shall meet the requirements of the above paragraph or be provided with a 6.5 foot (1.98 meters) high protective barrier or means to allow the operator to be at least nine (9) feet (2.7 meters) from the tube housing assembly while making exposure if the equipment has been installed or relocated after January 1, 2006.

For equipment installed before January 1, 2006, there must exist a means to allow the operator to be at least six (6) feet (1.8 meters) from the tube housing assembly while making exposure.

4. **Reproducibility**.

When the equipment is operated on an adequate power supply as specified by the manufacturer, the estimated coefficient of variation of radiation exposures shall be no greater than 0.05, for any specific combination of selected technique factors.

f. **mA/mS linearity**.

The following requirements apply when the equipment is operated on a power supply as specified by the manufacturer for any fixed x-ray tube potential within the range of forty percent (40%) to one hundred percent (100%) of the maximum rated:

1. Equipment having independent selection of x-ray tube current (mA). The average ratios (X_1) of exposure to the indicated milliampere-seconds product, in units of C $kg^{-1}mAs^{-1}$ (or mR/mAs), obtained at any two (2) consecutive tube current settings shall not differ by more than 0.10 times their sum:

$$(X_1 - X_2) < 0.1 (X_1 + X_2)$$

where X_1 and X_2 are the average values obtained at each of two (2) consecutive tube current settings, or at two settings differing by no more than a factor of two (2) where the tube current selection is continuous.

2. Equipment having a combined x-ray tube current-exposure time product (mAs) selector, but not a separate tube current (mA) selector. The average ratios (X_1) of exposure to the indicated milliampere-seconds product, in units of C $kg^{-1}mAs^{-1}$ (or mR/mAs), obtained at any two (2) consecutive mAs selector settings shall not differ by more than 0.10 times their sum:

$$(X_1 - X_2) < 0.1 (X_1 + X_2)$$

where X_1 and X_2 are the average values obtained at any two (2) mAs selector settings, or at two (2) settings differing by no more than a factor of two (2) where the mAs selector provides continuous selection.

3. **Measuring compliance**.

Determination of compliance shall be based on ten (10) exposures taken within a time period of one (1) hour, at each of the two (2) settings. These two (2) settings may include any two (2) focal spot sizes except where one (1) is equal to or less than 0.45 millimeters and the other is greater than 0.45 millimeters. For purposes of this requirement, focal spot size is the nominal focal spot size specified by the x-ray tube manufacturer.

g. **Accuracy**.

Deviation of technique factors from indicated values for kVp and exposure time (if time is independently selectable) shall not exceed the limits specified for that system by its manufacturer. In the absence of manufacturer's specifications, the deviation shall not exceed ten percent (10%).

h. **kVp limitations**.

Dental x-ray machine with a nominal fixed kVp of less than 50 kVp shall not be used to make diagnostic dental radiographs of humans.

i. **Administrative controls**.

1. Patient and film holding devices shall be used when the techniques permit.

2. The tube housing and the Patient Imaging Device (PID) shall not be hand-held during an exposure.

RH-1606.i. (Cont'd)

3. The x-ray system shall be operated in such a manner that the useful beam at the patient's skin does not exceed the requirements.

4. Dental fluoroscopy without image intensification shall not be used.

NOTE: In many cases structural materials of ordinary walls suffice as a protective barrier without addition of special shielding material.

RH-1607.- 1608. Deleted. See Section 11, "Therapeutic Radiation Machines."

RH-1609. **Veterinary Medicine**.

a. **Equipment**.

1. The protective tube housing shall be equivalent to general x-ray tube.

2. Diaphragms or cones shall be provided for collimating the useful beam to the area of clinical interest and shall provide the same degree of protection as is required of the housing.

3. The total filtration permanently in the useful beam shall not be less than 0.5 millimeters aluminum equivalent for machines operating up to 50 kVp, 1.5 millimeters aluminum equivalent for machines operating between 50 and 70kVp, and 2.5 millimeters aluminum equivalent for machines operating above 70 kVp.

b. **Operator protection**.

All wall, ceiling, and floor areas shall be equivalent or provided with applicable protective barriers. Stationary, mobile or portable x-ray systems shall be provided with either a two (2) meter (6.5 feet) high protective barrier for operator protections during exposures, or shall be provided with means to allow the operator to be at least 2.7 meters (9 feet) from the tube housing assembly during exposures if the equipment has been installed or relocated after January 1, 2006.

For equipment installed before January 1, 2006, there must exist a means to allow the operator to be at least six (6) feet (1.8 meters) from the tube housing assembly during exposures.

RH-1609. (Cont'd)

c. **Operating procedures**.

1. No individual other than the operator shall be in the x-ray room while exposures are being made unless such individual's assistance is required, and

2. The operator shall stand behind the protective barrier of nine (9) feet from the useful beam and the animal during radiographic exposures, or

3. When an animal must be held in position during radiography, mechanical supporting or restraining devices should be used. If the animal must be held by an individual, that individual shall be protected with appropriate shielding devices, such as protective gloves and apron, and shall be so positioned that no part of the holder's body will be struck by the useful beam. The exposure of any individual used for this purpose shall be monitored.

RH-1610. **Mammography Systems**.

a. **Definitions**.

Accreditation body or body - An entity that has been approved by FDA accredit mammography facilities.

Action limits or action levels - The minimum and maximum values of a quality assurance measurement that can be interpreted as representing acceptable performance with respect to the parameter being tested. Values less than the minimum or greater than the maximum action limit or level indicate that corrective action must be taken by the facility. Action limits or levels are also sometimes called control limits or levels.

Air kerma - Kerma in a given mass of air. The unit used to measure the quantity of air kerma is the Gray (Gy). For x-rays with energies less than 300 kiloelectronvolts (keV), 1 Gy = 100 rad. In air, 1 Gy of absorbed dose is delivered by 114 roentgens (R) of exposure.

Breast implant - A prosthetic device implanted in the breast.

Calendar quarter - Any one of the following time periods during a given year: January 1 through March 31, April 1 through June 30, July 1 through September 30, or October 1 through December 31.

Category I - Medical educational activities that have been designated as Category I by the Accreditation Council for Continuing Medical Education (ACCME), the American Osteopathic Association (AOA), a state medical society, or an equivalent organization.

Certificate - The certificate described in the "Mammography Quality Standards Act," Subchapter I to Title 21 of the Code of Federal Regulations, paragraph (a) of Section 900.11.

Certification - The process of approval of a facility by FDA to provide mammography services.

Clinical image - A mammogram.

Consumer - An individual who chooses to comment or complain in reference to a mammography examination, including the patient or representative of the patient (e.g., family member or referring physician).

Continuing education unit or continuing education credit - One (1) contact hour of training.

Contact hour - An hour of training received through direct instruction.

Diagnostic Mammography - A problem solving radiographic procedure of higher intensity than screening mammography provided to women who are suspected to have breast pathology. Patients are usually referred for analyses of palpable abnormalities or for further evaluation of mammographically detected abnormalities. All images are immediately reviewed by the physicians interpreting the study, and additional views are obtained as needed. Physical examinations of the breast by the interpreting physician to correlate the radiologic findings is often performed as part of the study.

Direct instruction - Face-to-face interaction between instructor(s) and student(s), as when the instructor provides a lecture, conducts demonstrations, or reviews student performance; or the administration and correction of student examinations by an instructor(s) with subsequent feedback to the student(s).

Direct Supervision of Interpreting Physicians - During joint interpretation of mammograms, the supervising interpreting physician reviews, discusses, and confirms the diagnosis of the physician being supervised and signs the resulting report before it is entered into the patient's records.

Direct Supervision of Radiologic Technologists - During the performance of a mammography examination or survey of the facility's equipment and quality assurance program, the supervisor is present to observe and correct, as needed, the performance of the individual being supervised who is performing the examination or conducting the survey.

Established operating level - The value of a particular quality assurance parameter that has been established as an acceptable normal level by the facility's quality assurance program.

Facility - A hospital, outpatient department, clinic, radiology practice, mobile unit, office of a physician, or other facility that conducts mammography activities, including the following: operation of equipment to produce a mammogram, processing of the mammogram, initial interpretation of the mammogram, and maintaining viewing conditions for the interpretation. This term does not include a facility of the Department of Veterans Affairs.

FDA - The Food and Drug Administration.

First allowable time - The earliest time a resident physician is eligible to take the diagnostic radiology boards from an FDA-designated certifying body. The "first allowable time" may vary with the certifying body.

Interim regulations - The regulations entitled "Requirements for Accrediting Bodies of Mammography Facilities" (58 FR 67558-67565), published by FDA on December 21, 1993, and amended on September 30, 1994 (59 FR 49808-49813). These regulations established the standards that had to be met by mammography facilities in order to lawfully operate between October 1, 1994, and April 28, 1999.

Interpreting physician - A licensed physician who interprets mammograms and who meets the requirements set forth in the "Mammography Quality Standards Act," Subchapter I to Title 21 of the Code of Federal Regulations, paragraph (a)(1) of Section 900.12.

Kerma - The sum of the initial energies of all the charged particles liberated by uncharged ionizing particles in a material of given mass.

Laterality -The designation of either the right or left breast.

Lead interpreting physician - The interpreting physician assigned the general responsibility for ensuring that a facility's quality assurance program meets all of the requirements in 21 CFR Part 16 and the "Mammography Quality Standards Act," Subchapter I to 21 CFR, paragraphs (d) through (f) of Section 900.12. The administrative title and other supervisory responsibilities of the individual, if any, are left to the discretion of the facility.

Mammogram - A radiographic image produced through mammography.

Mammographic modality - A technology, within the scope of 42 U.S.C. 263b, for radiography of the breast. Examples are screen-film mammography and digital mammography.

Mammography - Radiography of the breast, but for the purposes of this part, does not include: radiography of the breast performed during invasive interventions for localization or biopsy procedures; or radiography of the breast performed with an investigational mammography device as part of a scientific study conducted in accordance with FDA's investigational device exemption regulations.

Mammography equipment evaluation - An onsite assessment of mammography unit or image processor performance by a medical physicist for the purpose of making a preliminary determination as to whether the equipment meets all of the applicable standards set forth in the "Mammography Quality Standards Act," Subchapter I to Title 21 of the Code of Federal Regulations, paragraphs (b) and (e) of Section 900.12.

Mammography medical outcomes audit - A systematic collection of mammography results and the comparison of those results with outcomes data.

Mammography unit or units - An assemblage of components for the production of x-rays for use during mammography, including, at a minimum: an x-ray generator, and x-ray control, a tube housing assembly, a beam limiting device, and the supporting structures for these components.

Mean optical density - The average of the optical densities measured using phantom thickness of two (2), four (4), and six (6) centimeters with values of kilovolt peak (kVp) clinically appropriate for those thicknesses.

Medical physicist - A person trained in evaluating the performance of mammography equipment and facility quality assurance programs and who meets the qualifications for a medical physicist set forth in the "Mammography Quality Standards Act," Subchapter I to Title 21 of the Code of Federal Regulations, paragraph (a)(3) of Section 900.12.

MQSA - The Mammography Quality Standards Act.

Multi-reading – Two (2) or more physicians, at least one (1) of whom is an interpreting physician, interpreting the same mammogram.

Patient - Any individual who undergoes a mammography evaluation in a facility, regardless of whether the person is referred by a physician or is self-referred.

Phantom - A test object used to simulate radiographic characteristics of compressed breast tissue and containing components that radiographically model aspects of breast disease and cancer.

Phantom image - A radiographic image of a phantom.

Physical science - Physics, chemistry, radiation science (including medical physics and health physics), and engineering.

Positive mammogram - A mammogram that has an overall assessment of findings that are either "suspicious" or "highly suggestive of malignancy."

Provisional certificate - The provisional certificate described in 21 CFR Section 900.11(b)(2).

Qualified instructor - An individual whose training and experience adequately prepares him or her to carry out specified training assignments. Interpreting physicians, radiologic technologists, or medical physicists who meet the requirements of 21 CFR Section 900.12(a) would be considered qualified instructors in their respective areas of mammography. Other examples of individuals who may be qualified instructors for the purpose of providing training to meet the regulations of this part include, but are not limited to, instructors in a post-high school training institution and manufacturer's representatives

Quality control technologist - An individual meeting the requirements of 21 CFR Section 900.12(a)(2) who is responsible for those quality assurance responsibilities not assigned to the lead interpreting physician or to the medical physicist.

Radiographic equipment - X-ray equipment used for the production of static x-ray images.

Radiologic technologist - An individual specifically trained in the use of radiographic equipment and the positioning of patients for radiographic examinations and who meets the requirements set forth in 21 CFR Section 900.12(a)(2).

Review physician - A physician who, by meeting the requirements set out in 21 CFR Section 900.4(c)(5), is qualified to review clinical images on behalf of the accreditation body.

Screening mammography - Radiographic procedure provided to a woman, who has no signs or symptoms of breast cancer, for the purpose of early detection of breast cancer. The procedure entails two views of each breast and includes a physician's interpretation of the results of the procedure.

Serious adverse event - An adverse event that may significantly compromise clinical outcomes, or an adverse event for which a facility fails to take appropriate corrective action in a timely manner.

Serious compliant - A report of a serious adverse event.

Standard breast - A 4.2 centimeter (cm) thick compressed breast consisting of fifty percent (50%) glandular and fifty percent (50%) adipose tissue.

Survey - An on-site physics consultation and evaluation of a facility quality assurance program performed by a medical physicist.

Time cycle - The film development time.

Traceable to a national standard - An instrument is calibrated at either the National Institute of Standards and Technology (NIST) or at a calibration laboratory that participates in a proficiency program with NIST at least once every two (2) years and the results of the proficiency test conducted within 24 months of calibration show agreement within plus or minus three percent (± 3%) of the national standard in the mammography energy range.

b. **Accreditation**.

1. All facilities performing screening or diagnostic mammography shall be accredited every three (3) years by the Arkansas Department of Health or the American College of Radiology. Such accreditation shall be in accordance with the Food and Drug Administration (FDA) 21 CFR Part 16 and the "Mammography Quality Standards Act," Subchapter I to Chapter I of 21 CFR.

2. No mammography shall be performed in an unaccredited facility after January 1, 1990. The owners of any unaccredited facility where in mammography is performed after January 1, 1990 shall be subject to a civil penalty imposed by the Arkansas Department of Health in an amount not to exceed one hundred dollars ($100) for each day the facility operates without accreditation by the Department.

c. **Quality standards**.

1. **Personnel**.

The following requirements apply to personnel involved in any aspect of mammography, including production, processing, and interpretation of mammograms and related quality assurance activities.

A. **Interpreting physicians**.

Interpreting physicians shall meet the minimum requirements of 21 CFR Part 900.12(a)(1) of the Food and Drug Administration's "Mammography Quality Standards Act."

B. **Radiological technologist**.

i. Radiological technologists shall meet the minimum requirements of 21 CFR Part 900.12.(a)(2) of the Food and Drug Administration's "Mammography Quality Standards Act."

ii. Licensed by the State of Arkansas as a Registered Radiologic Technologist.

C. **Mammography imaging medical physicist**.

i. Mammography imaging medical physicists shall meet the minimum requirements of 21 CFR Part 900.12.(a)(3) of the Food and Drug Administration's "Mammography Quality Standards Act."

ii. All mammography imaging medical physicists must be registered with the State as a vendor as required by RH-34.

2. **Medical physicist's survey requirements**.

A. Medical physicist's surveys must be performed at least annually.

B. A mammography medical physicist who meets the qualification requirements of RH-1610.c.1.C. must sign all physicist survey reports.

C. Mammography medical physicists who sign a facility survey report must have been present in that facility during the survey.

D. Medical physicist's surveys must meet the requirements of 21 CFR Part 900.12(e)(9) of the Food and Drug Administration (FDA).

3. **Obtaining and preserving records**.

All reasonable efforts must be made to obtain any of the beneficiary's previous mammogram records, including original images and films, copies of written reports prepared by interpreting physicians, and other relevant information pertinent to previous mammograms that might be available from others, for comparison with current mammogram records. All reporting and record keeping must meet the requirements of 21 CFR Part 900.12(c) of the Food and Drug Administration (FDA).

4. **Equipment**.

The equipment used to perform mammography should be specifically designed for mammography and must meet the following standards:

A. **Food and Drug Administration (FDA), Subchapter I entitled "Mammography Quality Standards Act."**

21 CFR Part 900.12(b).

B. **Food and Drug Administration (FDA), Subchapter J entitled "Radiological Health."**

Certified equipment must meet the FDA performance standards for diagnostic x-ray systems and their major components at 21 CFR 1020.30 and FDA's standards for radiographic equipment at 21 CFR 1020.31.

C. **Focal spot size**.

The measured focal spot size of the x-ray tube should not exceed 0.7 mm.

D. **Control panel indicators**.

The equipment must have a control panel that includes a device (usually a milliammeter) or means for an audible signal to give positive indication of the production of x-rays whenever the x-ray tube is energized. The control panel must include appropriate indicators (labeled control settings of meters that show the physical factors such as kilovoltage potential [kVp], milliampere seconds [mAs], exposure time, or whether timing is automatic) used for exposure.

E. All mammography units must be registered with the State of Arkansas as required by RH-21.

F. **Mammography equipment evaluations**.

All variable parameters of the equipment must be evaluated and adjusted as needed to comply with 21 CFR Part 900.12(e)(10) of the FDA's "Mammography Quality Standards Act." This includes but is not limited to the following:

i. When the equipment is installed;

ii. After any major changes or replacement of parts;

iii. When quality assurance tests indicate that calibration or other maintenance is needed;

iv. When equipment is disassembled and reassembled.

5 **Safety standards**.

Mammograms must be conducted using equipment and operating procedures free of unnecessary hazards and providing minimum radiation exposure to patients, personnel, and other persons in the immediate environment.

A. **Safety precautions**.

Proper safety precautions must be maintained. This includes adequate shielding for patients, personnel, and facilities. The equipment must be operable only from a shielded position.

B. **Exposure badges**.

Personnel operating the equipment must be monitored in accordance with RH-1301. and RH-1302.

C. **Equipment inspection**.

Periodic inspection of equipment and shielding must be made by a staff or consultant medical physicist or by a physicist approved by an appropriate State or local government agency as meeting the qualification requirements of RH-1610. Identified hazards must be promptly corrected.

D. **Protection against electrical hazards**.

All equipment must be shockproof and grounded.

6. **Quality assurance**.

Each facility must establish and maintain a quality assurance program that meets the requirements of 21 CFR Part 900.12(d) of the FDA's "Mammography Quality Standards Act."

A. **Responsibilities for the lead interpreting physician**.

The lead interpreting physician has the following responsibility:

i. Ensuring that the facility's quality assurance program meets all the requirements of 21 CFR Part 900.12(d) of the FDA's "Mammography Quality Standards Act."

B. **Responsibilities for the mammography medical physicist**.

The person furnishing medical physics support has the overall responsibility for establishing and conducting the ongoing equipment quality assurance program. That individual's specific duties must include:

i. The duties outlined in 21 CFR Part 900.12 (d)(iii) of the FDA's "Mammography Quality Standards Act."

ii. Conducting or training others to conduct equipment performance monitoring functions;

iii. Analyzing the monitoring results to determine if there are any problems requiring correction; and

iv. Carrying out or arranging for the necessary corrective actions as well as for the calibrations and other preventive maintenance.

v. Conduct an annual survey of the facility's equipment quality assurance program as required by 21 CFR Part 900.12(e)(9) of the FDA's "Mammography Quality Standards Act."

vi. Submit a written report describing the results of the survey as required by 21 CFR Part 900.12(e)(9)(iii) of the FDA's "Mammography Quality Standards Act."

C. **Responsibilities of the quality control technologist**.

The quality control technologist must perform the tasks within the quality assurance program that are not assigned to the lead interpreting physician or the medical physicist.

D. **Quality assurance**.

The facility must ensure the quality of mammography by maintaining a quality assurance program that meets the requirements found in 21 CFR Part 900.12(e) of the FDA's "Mammography Quality Standards Act" and verifying that the action limits described in Part 900.12(e) have been met. These tests and their frequencies are as follows:

i. **Daily**.

Processor performance tests, which includes assessment of base plus fog density, mid-density, and density difference.

ii. **Weekly**.

Image quality evaluation test using an FDA-approved phantom.

iii. **Quarterly**.

Fixer retention in film test, repeat film analysis.

iv. **Semi-annually**.

Dark room fog evaluation, screen film contact test and compression device evaluation.

v. **Annual testing**.

Automatic exposure control performance, kilovoltage peak (kVp) accuracy and reproducibility, focal spot condition, breast entrance air kerma and AEC reproducibility, dosimetry, x-ray field/light field/image receptor/compression paddle alignment, uniformity of screen speed, radiation output, system artifacts, and decompression.

vi. **Mobile units**.

The facility shall verify that mammography units used to produce mammograms at more than one location meet the requirements in paragraphs (e)(1) through (e)(6) of 21 CFR Part 900.12. In addition, at each examination location, before any examinations are conducted, the facility shall verify satisfactory performance of such units using a test method that establishes the adequacy of the image quality produced by the unit.

vii. **Quality control tests - other modalities**.

For systems with image receptor modalities other than screen-film, the quality assurance program shall be substantially the same as the quality assurance program recommended by the image receptor manufacturer, except that the maximum allowable dose shall not exceed the maximum allowable dose for screen-film systems in the FDA 21 CFR Part 900.12 (e)(5)(vi).

viii. The facility shall establish and implement adequate protocols for maintaining darkroom, screen, and view box cleanliness and shall document that all cleaning procedures are performed at the frequencies specified in the protocols.

ix. **Infection control**.

Facilities shall establish and comply with a system specifying procedures to be followed by the facility for cleaning and disinfecting mammography equipment after contact with blood or other potentially infectious materials. This system shall specify the methods for documenting facility compliance with the infection control procedures established and shall comply with the requirements in the FDA 21 CFR Part 900.12(e)(13).

E. **Evaluation of monitoring results**.

Quality assurance test results must be evaluated in a timely manner by the individual that is responsible for performing the test to ensue compliance with 21 CFR Part 900.12(e)(8) of the FDA "Mammography Quality Standards Act." The responsible individuals are limited to the lead interpreting physician, the medical physicist and the quality control technologist.

F. **Medical outcomes audit**.

Each facility must establish and maintain a medical outcomes audit program to follow-up positive mammographic assessments and to correlate pathology results to the interpreting physician's findings. This program must comply with 21 CFR Part 900.12(f) of the FDA "Mammography Quality Standards Act."

G. **Procedures and techniques for mammography of patients with breast implants**.

Each facility must have procedures, which specify techniques, and procedures for imaging patients with breast implants. These procedures must comply with 21 CFR Part 900.12(g) of the FDA "Mammography Quality Standards Act."

H. **Consumer complaint mechanism**.

Each facility must have a consumer complaint mechanism. This mechanism must comply with 21 CFR Part 900.12(h) of the FDA "Mammography Quality Standards Act."

7. **Standards for diagnostic mammography**.

Facilities who wish to be accredited for diagnostic mammography shall, in addition to meeting all of the requirements for mammography also:

A. Have the interpreting physician as defined in RH-1610.c.1.A. present during all diagnostic mammography for direct supervision of the exam and film interpretation.

B. Have mammography systems with cone down compression and magnification capabilities, to enhance film interpretation.

d. **Applications and fees**.

Applications for accreditation or renewal shall be made on forms supplied by the Department. Evidence of compliance with all of the requirements for performing screening and/or diagnostic mammography and the accreditation fee must be included with the application.

e. **Additional review and patient notification**.

1. When quality assurance tests indicate that calibration is needed, and the Department believes that mammography quality at a facility has been compromised and may present a serious risk to human health, the facility shall provide clinical images and other relevant information, as specified by the Department, for review by the accreditation body. This additional mammography review will help the Department to determine whether the facility is in compliance with RH-1610. and, if not, whether there is a need to notify affected patients, their physicians or the public that the reliability, clarity and accuracy of interpretation of mammograms has been compromised.

2. If the Department determines that any activity related to the provision of mammography at a facility may present a serious risk to human health such that patient notification is necessary, the facility shall notify patients or their designees, their physicians or the public of action that may be taken to minimize the effects of the risk. Such notification shall occur within a timeframe and in a manner specified and approved by the Department.

f. **Retention of personnel records**.

Facilities shall maintain records to document the qualifications of all personnel who worked at the facility as interpreting physicians, radiologic technologists, or medical physicists. These records must be available for review by the MQSA inspectors. Records of personnel no longer employed by the facility should not be discarded until the next annual inspection has been completed, and FDA has determined that the facility is in compliance with MQSA personnel requirements.

g. **Quality assurance record keeping**.

All quality assurance record keeping shall meet the requirements of 21 CFR Part 900.12(d)(2) of the Food and Drug Administration (FDA) "Mammography Quality Standards Act." The lead interpreting physician, quality control technologist, and medical physicist shall ensure that records concerning mammography technique and procedures, quality control (including monitoring data, problems detected by analysis of that data, corrective actions, and the effectiveness of the corrective actions), safety, protection, and employee qualifications to meet assigned quality assurance tasks, are properly maintained and updated. The quality control records shall be kept for each test specified in paragraphs (e) and (f) of 21 CFR Part 900.12 until the next annual inspection has been completed, and FDA has determined that the facility is in compliance with the quality assurance requirements or until the test has been performed two additional times at the required frequency, whichever is longer.

h. **Clinical image quality**.

Clinical images produced by any certified facility must continue to comply with the standards for clinical image quality established by that facility's accreditation body.

RH-1611. **Bone Densitometry**.

a. Bone densitometry systems shall be:

1. Certified by the U.S. Department of Health and Human Services.

2. Registered in accordance with these Regulations; and

3. Maintained and operated in accordance with the manufacturer's specifications.

b. Operators of bone densitometry systems shall be:

1. Licensed, certified, or permitted as a radiologic technologist by the Department; or

2. Licensed as a practitioner of the healing arts; or

3. Permitted or approved by the Department as a bone densitometry operator.

c. During the operation of any bone densitometry system:

1. The operator, ancillary personnel, and members of the general public shall be positioned at least one meter from the patient and bone densitometry system during the examination.

2. The operator shall advise the patient the bone densitometry examination is a type of x-ray procedure.

d. The registrant shall keep maintenance records for bone densitometry systems as prescribed. These records shall be maintained for inspection by the Department recordkeeping timelines as appropriate.

e. Bone densitometry on human patients shall be conducted only:

1. Under a prescription of a licensed practitioner of the healing arts; or

2. Under a screening program approved by the Department.

f. Any person proposing to conduct a bone densitometry screening program shall submit the information outlined in Schedule A to Section 3 with the exception of g, h, i, j, k, and m, and include the name and address of the individual who will interpret the screening results.

SCHEDULE A TO SECTION 3

INFORMATION TO BE SUBMITTED BY PERSONS PROPOSING TO CONDUCT HEALING ARTS SCREENING

Persons requesting that the Department approve a healing arts screening program shall submit the following information and evaluation:

a. Name and address of the applicant and, where applicable, the names and addresses of agents within this State;

b. Diseases or conditions for which the x-ray examinations are to be used in diagnoses;

c. A detailed description of the x-ray examinations proposed in the screening program;

d. Description of the population to be examined in the screening program, i.e., age, sex, physical condition, and other appropriate information;

e. An evaluation of any known alternate methods not involving ionizing radiation which could achieve the goals of the screening program and why these methods are not used instead of the x-ray examinations;

f. An evaluation by a qualified expert of the x-ray system(s) to be used in the screening program. The evaluation by the qualified expert shall show that such system(s) do satisfy all requirements of these Regulations. The evaluation shall include a measurement of patient exposures from the x-ray examinations to be performed;

g. A description of the diagnostic x-ray quality control program;

h. A copy of the technique chart for the x-ray examination procedures to be used;

i. The qualifications of each individual who will be operating the x-ray system(s);

j. The qualifications of the individual who will be supervising the operators of the x-ray system(s). The extent of supervision and the method of work performance evaluation shall be specified;

k. The name and address of the individual who will interpret the radiograph(s);

l. A description of the procedures to be used in advising the individual screening procedure and any further medical needs indicated;

m. A description of the procedures for the retention or disposition of the radiographs and other records pertaining to the x-ray examinations;

n. An indication of the frequency of screening and the duration of the entire screening program.

RH-1612. **Scope and Purpose – Analytical X-ray Equipment**.

This Part provides special requirements for analytical x-ray equipment. The requirements of this Part are in addition to, and not in substitution for, applicable requirements in other Parts of these Regulations.

a. **Definitions**.

Analytical x-ray equipment - X-Ray equipment used for x-ray diffraction fluorescence analysis or spectroscopy.

Analytical x-ray system - A group of local and remote components utilizing x-rays to determine the elemental composition or to examine the microstructure of materials. Local components include those that are struck by x-rays such as radiation source housings, port and shutter assemblies, collimators, sample holders, cameras, goniometers, detectors and shielding. Remote components include power supplies, transformers, amplifiers, readout devices, and control panels.

Fail-safe characteristics - A design feature which causes beam port shutters to close or otherwise prevents emergence of the primary beam, upon the failure of a safety or warning device.

Local components - Part of an analytical x-ray system and include areas exposed to x-rays, such as radiation source housings, port and shutter assemblies, collimators, sample holders, cameras, goniometers, detectors and shielding, but does not include power supplies, transformers, amplifiers, readout devices and control panels.

Normal operating procedures - Operating procedures for conditions suitable for analytical purposes with shielding and barriers in place. These do not include maintenance but do include routine alignment procedures. Routine and emergency radiation safety considerations are part of these procedures.

Open-beam configuration - An analytical x-ray system in which an individual could accidentally place some part of his/her body in the primary beam path during normal operation.

Primary beam - Ionizing radiation which passes through an aperture of the source housing by a direct path from the x-ray tube located in the radiation source housing.

RH-1612. (Cont'd)

b. **Equipment Requirements**.

1. **Safety device**.

A device which prevents the entry of any portion of an individual's body into the primary x-ray beam path or which causes the beam to be shut off upon entry into its path shall be provided on all open-beam configurations. A registrant may apply to the Department for an exemption from the requirement of a safety device. Such application shall include:

A. A description of the various safety devices that have been evaluated;

B. The reason each of these devices cannot be used; and

C. A description of the alternative methods that will be employed to minimize the possibility of an accidental exposure, including procedures to assure that operators and others in the area will be informed of the absence of safety devices.

2. **Warning devices**.

A. Open-beam configurations shall be provided with a readily discernible indication of:

i. X-ray tube status **(ON-OFF)** located near the radiation source housing, if the primary beam is controlled in this manner; and/or

ii. Shutter status **(OPEN-CLOSED)** located near each port on the radiation source housings, if the primary beam is controlled in this manner.

B. Warning devices shall be labeled so that their purpose is easily identified. On equipment installed after January1, 1979, warning devices shall have fail-safe characteristics.

3. **Ports**.

Unused ports on radiation machine source housings shall be secured in the closed position in a manner which will prevent casual opening.

4. **Labeling**.

All analytical x-ray equipment shall be labeled with a readily discernible sign or signs bearing the radiation symbol and the words:

A. "**CAUTION - HIGH INTENSITY X-RAY BEAM**," or words having a similar intent, on the x-ray source housing; and

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B. "**CAUTION RADIATION - THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED**," or words having a similar intent, near any switch that energizes an x-ray tube.

5. **Shutters**.

On open-beam configurations installed after January 1, 1979, each port on the radiation source housing shall be equipped with a shutter that cannot be opened unless a collimator or a coupling has been connected to the port.

6. **Warning lights**.

A. An easily visible warning light labeled with the words "**X-RAY ON**" or words having a similar intent, shall be located near any switch that energizes an x-ray tube and shall be illuminated only when the tube is energized.

B. On equipment installed after January 1, 1979, warning lights shall have fail-safe characteristics.

7. **Radiation source housing**.

Each radiation source housing shall be subject to the following requirements:

A. Each x-ray tube housing shall be equipped with an interlock that shuts off the tube if it is removed from the radiation source housing or if the housing is disassembled.

8. **Generator cabinet**.

Each x-ray generator shall be supplied with a protective cabinet which limits leakage radiation measured at a distance of five (5) centimeters from its surface such that it is not capable of producing a dose in excess of 0.25 millirem in one hour.

c. **Area Requirements**.

1. **Radiation levels**.

The local components of an analytical x-ray system shall be located and arranged and shall include sufficient shielding or access control such that no radiation levels exist in any area surrounding the local component group which could result in a dose to an individual present therein in excess of the dose limits given in RH-1208. These levels shall be met at any specified tube rating.

2. **Surveys**.

A. Radiation surveys, as required by RH-1300., of all analytical x-ray systems sufficient to show compliance with RH-1612.c.1. shall be performed:

i. Upon installation of the equipment;

ii. Following any change in the initial arrangement, number or type of local components in the system;

iii. Following any maintenance requiring the disassembly or removal of a local component in the system;

iv. During the performance of maintenance and alignment procedures, if the procedures require the presence of a primary x-ray beam when any local component in the system is disassembled or removed;

v. Any time a visual inspection of the local components in the system reveals an abnormal condition; and

vi. Whenever personnel monitoring devices show a significant increase over the previous monitoring period or the readings are approaching the limits specified in RH-1200.

B. Radiation survey measurements shall not be required if a registrant can demonstrate compliance to the satisfaction of the Department with RH-1612.c.1. in some other manner.

3. **Posting**.

Each area or room containing analytical x-ray equipment shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words "**CAUTION - X-RAY EQUIPMENT**" or words having a similar intent.

d. **Operating Requirements**.

1. **Procedures**.

Normal operating procedures shall be written and available to all analytical x-ray equipment workers. No person shall be permitted to operate analytical x-ray equipment in any manner other than that specified in the procedures unless such person has obtained written approval of the Radiation Safety Officer.

2. **Bypassing**.

No person shall bypass a safety device unless such person has obtained the approval of the Radiation Safety Officer. When a safety device has been bypassed, a readily discernible sign bearing the words "**SAFETY DEVICE NOT WORKING**," or words having a similar intent, shall be placed on the radiation source housing.

3. **Repair or modification of x-ray tube systems**.

Except as specified in RH-1612.d.2., no operation involving removal of covers, shielding materials or tube housings or modifications to shutters, collimators or beam stops shall be performed without ascertaining that the tube is off and will remain off until safe conditions have been restored. The main switch, rather than interlocks, shall be used for routine shutdown in preparation for repairs.

RH-1612. (Cont'd)

e. **Personnel Requirements**.

1. **Instruction**.

A. No person shall be permitted to operate or maintain analytical x-ray equipment unless such person has received instruction in and demonstrated competence as to:

i. Identification of radiation hazards associated with the use of the equipment;

ii. Significance of the various radiation warning and safety devices incorporated into the equipment or the reasons they have not been installed on certain pieces of equipment and the extra precautions required in such cases;

iii. Proper operating procedures for the equipment;

iv. Symptoms of an acute localized exposure; and

v. Proper procedures for reporting an actual or suspected exposure.

2. **Personnel monitoring**.

A. Finger or wrist dosimetric devices shall be provided to and shall be used by:

i. Analytical x-ray equipment workers using systems having an open-beam configuration and not equipped with a safety device; and

ii. Personnel maintaining analytical x-ray equipment if the maintenance procedures require the presence of a primary x-ray beam when any local component in the analytical x-ray system is disassembled or removed.

B. Reported dose values shall not be used for the purpose of determining compliance with RH-1200. and RH-1208. unless evaluated by a qualified expert.

RH-1613. **Computed Tomography**.

a. **Definitions**.

Computed tomography dose index (CTDI) - The integral from 7T to +7T of the dose profile along a line perpendicular to the tomographic plane divided by the product of the nominal tomographic section thickness and the number of tomograms produced in a single scan.

NOTE: This definition assumes that the dose profile is centered around z = 0 and that, for a multiple tomogram system, the scan increment between adjacent scans is nT.

Contrast scale (CS) - The change in the linear attenuation coefficient per CTN relative to water, that is:

$\overline{CTN}_x$ = of the material of interest; and
$\overline{CTN}_w$ = of water.

CT conditions of operation - All selectable parameters governing the operation of a CT x-ray system including, but not limited to, nominal tomographic section thickness, filtration, and the technique factors as defined.

CT gantry - The tube housing assemblies, beam-limiting devices, detectors, and the supporting structures and frames that hold these components.

CT number (CTN) - The number used to represent the x-ray attenuation associated with each elemental area of the CT image.

$$\overline{CTN} = \frac{k(\mu_x - \mu_w)}{\mu_w}$$

where: k = A constant, a normal value of 1,000 when the Houndsfield scale of CTN is used;

μ_x = Linear attenuation coefficient of the material of interest; and

μ_w = Linear attenuation coefficient of water.

Dose profile - The dose as a function of position along a line.

Elemental area - The smallest area within a tomogram for which the x-ray attenuation properties of a body are depicted. (See also "Picture element.")

Multiple tomogram system - A computed tomography x-ray system that obtains x-ray transmission data simultaneously during a single scan to produce more than one tomogram.

Noise - The standard deviation of the fluctuation in CTN expressed as a percentage of the attenuation coefficient of water. Its estimate (S_n) is calculated using the following expression:

$$S_n = \frac{100 \cdot \overline{CS} \cdot s}{\mu_w}$$

where: $\overline{CS}$ = Linear attenuation coefficient of the material of interest;

μ_w = Linear attenuation coefficient of water; and

s = Standard deviation of the CTN of picture elements in a specified area of the CT image.

Nominal tomographic section thickness - The full width at half-maximum of the sensitivity profile taken at the center of the cross-sectional volume over which x-ray transmission data are collected.

Picture element - An elemental area of a tomogram.

Reference plane - A plane that is displaced from and parallel to the tomographic plane.

Scan - The complete process of collecting x-ray transmission data for the production of a tomogram. Data can be collected simultaneously during a single scan for the production of one or more tomograms.

Scan increment - The amount of relative displacement of the patient with respect to the CT x-ray system between successive scans measured along the direction of such displacement.

Scan sequence - A pre-selected set of two or more scans performed consecutively under pre-selected CT conditions of operation.

Scan time - The period of time between the beginning and end of x-ray transmission data accumulation for a single scan.

Single tomogram system - A CT x-ray system that obtains x-ray transmission data during a scan to produce a single tomogram.

Tomographic plane - That geometric plane which is identified as corresponding to the output tomogram.

Tomographic section - The volume of an object whose x-ray attenuation properties are imaged in a tomogram.

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b. **Requirements for equipment**.

1. **Termination of exposure**.

A. Means shall be provided to terminate the x-ray exposure automatically by either de-energizing the x-ray source or shuttering the x-ray beam in the event of equipment failure affecting data collection. Such termination shall occur within an interval that limits the total scan time to no more than 110 percent (110%) of its preset value through the use of either a backup timer or devices which monitor equipment function.

B. A visible signal shall indicate when the x-ray exposure has been terminated

C. The operator shall be able to terminate the x-ray exposure at any time during a scan, or series of scans under CT x-ray system control, of greater than one-half second duration.

2. **Tomographic plane indication and alignment**.

A. For any single tomogram system, means shall be provided to permit visual determination of the tomographic plane or a reference plane offset from the tomographic plane.

B. For any multiple tomogram system, means shall be provided to permit visual determination of the location of a reference plane. This reference plane can be offset from the location of the tomographic planes.

C. If a device is using a light source, the light source shall provide illumination levels sufficient to permit visual determination of the location of the tomographic plane or reference plane under ambient light conditions of up to 500 lux.

3. **Beam-on and shutter status indicators and control switches**.

A. The CT x-ray control and gantry shall provide visual indication whenever x-rays are produced and, if applicable, whether the shutter is open or closed.

B. Each emergency button or switch shall be clearly labeled as to its function.

4. **Indication of CT conditions of operation**.

A. The CT x-ray system shall be designed such that the CT conditions of operation to be used during a scan or a scan sequence shall be indicated prior to the initiation of a scan or a scan sequence. On equipment having all or some of these conditions of operation at fixed values, this requirement may be met by permanent markings. Indication of CT conditions of operation shall be visible from any position from which scan initiation is possible.

B. **Extraneous radiation**.

When data are not being collected for image production, the radiation adjacent to the tube port shall not exceed that permitted by RH-1602.b.3.

C **Maximum surface Computed Tomography Dose Index (CTDI) identification**.

The angular position where the maximum surface CTDI occurs shall be identified to allow for reproducible positioning of a CT dosimetry phantom.

5. **Additional requirements applicable to CT x-ray systems containing a gantry manufactured after September 3, 1985**.

A. The total error in the indicated location of the tomographic plane or reference plane shall not exceed five (5) millimeters.

B. If the x-ray production period is less than one-half second, the indication of x-ray production shall be actuated for at least one-half second. Indicators at or near the gantry shall be discernible from any point external to the patient opening where insertion of any part of the human body into the primary beam is possible.

C. The deviation of indicated scan increment versus actual increment shall not exceed plus or minus one (±1) millimeter with any mass from 0 to 100 kilograms resting on the support device. The patient support device shall be incremented from a typical starting position to the maximum incremented distance or 30 centimeters, whichever is less, and then returned to the starting position. Measurement of actual versus indicated scan increment may be taken anywhere along this travel.

D. Premature termination of the x-ray exposure by the operator shall necessitate resetting of the CT conditions of operation prior to the initiation of another scan.

c. **Facility design requirements**.

1. **Aural communication**.

A. Provision shall be made for two-way aural communication between the patient and the operator at the control panel.

2. **Viewing systems**.

A. Windows, mirrors, closed-circuit television, or an equivalent shall be provided to permit continuous observation of the patient during irradiation and shall be so located that the operator can observe the patient from the control panel.

B. When the primary viewing system is by electronic means, an alternate viewing system (which may be electronic) shall be available for use in the event of failure of the primary viewing system.

d. **Surveys, calibrations, spot checks, and operating procedures**.

1. **Surveys**.

A. All CT x-ray systems shall have a survey made by, or under the direction of, a qualified expert. In addition, such surveys shall be done after any change in the facility or equipment which might cause a significant increase in radiation hazard.

B. The registrant shall obtain a written report of the survey from the qualified expert, and a copy of the report shall be made available to the Department upon request.

2. **Radiation calibrations**.

A. The calibration of the radiation output of the CT x-ray system shall be performed by, or under the direction of, a qualified expert who is physically present at the facility during such calibration.

B. The calibration of a CT x-ray system shall be performed at intervals specified by a qualified expert and after any change or replacement of components that, in the opinion of the qualified expert, could cause a change in the radiation output.

C. The calibration of the radiation output of a CT x-ray system shall be performed with a calibrated dosimetry system. The calibration of such system shall be traceable to a national standard. The dosimetry system shall have been calibrated within the preceding two (2) years.

D. CT dosimetry phantom(s) shall be used in determining the radiation output of a CT x-ray system. Such phantom(s) shall meet the following specifications and conditions of use:

i. CT dosimetry phantom(s) shall be right circular cylinders of polymethyl methacrylate of density 1.19 plus or minus 0.01 grams per cubic centimeter. The phantom(s) shall be at least 14 centimeters in length and shall have diameters of 32.0 centimeters for testing CT x-ray systems designed to image any section of the body and 16.0 centimeters for systems designed to image the head or for whole body scanners operated in the head scanning mode;

ii. CT dosimetry phantom(s) shall provide means for the placement of a dosimeter(s) along the axis of rotation and along a line parallel to the axis of rotation 1.0 centimeter from the outer surface and within the phantom. Means for the placement of dosimeters or alignment devices at other locations may be provided;

iii. Any effects on the doses measured due to the removal of phantom material to accommodate dosimeters shall be accounted for through appropriate corrections to the reported data or included in the statement of maximum deviation for the values obtained using the phantom; and

iv. All dose measurements shall be performed with the CT dosimetry phantom placed on the patient couch or support device without additional attenuation materials present.

E. The calibration shall be required for each type of head, body, or whole-body scan performed at the facility.

F. Calibration shall meet the following requirements:

i. The dose profile along the center axis of the CT dosimetry phantom for the minimum, maximum, and midrange values of the nominal tomographic section thickness used by the registrant shall be measurable. Where less than three (3) nominal tomographic thicknesses can be selected, the dose profile determination shall be performed for each available nominal tomographic section thickness;

ii. The CTDI along the two (2) axes shall be measured. (For the purpose of determining the CTDI, the manufacturer's statement as to the nominal tomographic section thickness for that particular system may be utilized.) The CT dosimetry phantom shall be oriented so that the measurement point 1.0 centimeter from the outer surface and within the phantom is in the same angular position within the gantry as the point of maximum surface CTDI identified. The CT conditions of operation shall correspond to typical values used by the registrant; and

iii. Spot checks shall be made in accordance with RH-1613.d.3.

G. Calibration procedures shall be in writing. Records of calibrations performed shall be maintained for inspection by the Department.

3. **Spot checks**.

A. The spot-check procedures shall be in writing and shall have been developed by a qualified expert.

B. The spot-check procedures shall incorporate the use of a CT dosimetry phantom which has a capability of providing an indication of contrast scale, noise, nominal tomographic section thickness, the resolution capability of the system for low and high contrast objects, and measuring the mean CTN for water or other reference material.

C. All spot checks shall be included in the calibration required by RH-1613.d.2. and at time intervals and under system conditions specified by a qualified expert.

D. Spot checks shall include acquisition of images obtained with the CT dosimetry phantom(s) using the same processing mode and CT conditions of operation as are used to perform calibrations. The images shall be retained, until a new calibration is performed, in two (2) forms as follows:

i. Photographic copies of the images obtained from the image display device; and

ii. Images stored in digital form on a storage medium compatible with the CT x-ray system.

E. Written records of the spot checks performed shall be maintained for inspection by the Department.

4. **Operating procedures**.

A. The CT x-ray system shall not be operated except by an individual who has been specifically trained in its operation.

B. Information shall be available at the control panel regarding the operation and calibration of the system. Such information shall include the following:

i. Dates of the latest calibration and spot checks and the location within the facility where the results of those tests may be obtained;

ii. Instructions on the use of the CT dosimetry phantom(s) including a schedule of spot checks appropriate for the system, allowable variations for the indicated parameters, and the results of at least the most recent spot checks conducted on the system;

RH-1613.d.4.B. (Cont'd)

iii. The distance in millimeters between the tomographic plane and the reference plane if a reference plane is utilized; and a current technique chart available at the control panel which specifies for each routine examination the CT conditions of operation and the number of scans per examination.

C. If the calibration or spot check of the CT x-ray system identifies that a system operating parameter has exceeded a tolerance established by the qualified expert, use of the CT x-ray system on patients shall be limited to those uses permitted by established written instructions of the qualified expert.

RH-1614.- RH-1699. Reserved.

PART H.
[RESERVED]

RH-1700.- RH-1702. Deleted.

RH-1703.- RH-1799. Reserved.

PART I.
LICENSES FOR INDUSTRIAL RADIOGRAPHY AND RADIATION SAFETY REQUIREMENTS FOR INDUSTRIAL RADIOGRAPHIC OPERATIONS

RH-1800. **General Provisions**.

a. **Purpose and scope.**

1. The regulations in this Part prescribe requirements for the issuance of licenses for the industrial use of sealed sources in industrial radiography and establish radiation safety requirements for persons utilizing sources of radiation in industrial radiography. The regulations in this Part apply to all licensees or registrants who use sources of radiation for industrial radiography. Except for the regulations in this Part clearly applicable only to sealed radioactive sources - radiation machines, accelerators, and sealed radioactive sources are covered by this Part. The provisions of this Part do not apply to medical uses of sources of radiation.

2. The requirements of this Part are in addition to, and not in substitution for, other applicable requirements of these Regulations. In particular, requirements in Sections 1, 2, 3, 4, 6, and 12 of these Regulations apply to applicants, licensees, and registrants subject to this Part.

b. **Specific licensing provisions**.

1. **Application for a specific license**.

A person, as defined in RH-1100., shall file an application for a specific license authorizing the use of sealed sources in industrial radiography in accordance RH-403. and RH-404.

2. **Specific licenses for industrial radiography**.

An application for a specific license for the use of licensed material in industrial radiography will be approved if:

A. The applicant satisfies the general requirements specified in RH-404., as applicable, and any special requirements contained in this Part;

B. The applicant submits an adequate program for training radiographers and radiographers' assistants that meets the requirements of RH-1802.b.;

C. The applicant submits adequate procedures for verifying and documenting the certification status of radiographers and for ensuring that the certification of individuals acting as radiographers remains valid;

D. The applicant submits written operating and emergency procedures as described in RH-1802.e.;

E. The applicant submits a description of a program for inspections of the job performance of each radiographer and radiographer's assistant at intervals not to exceed 6 months as described in RH-1802.b.5.;

F. The applicant submits a description of the applicant's overall organizational structure as it applies to the radiation safety responsibilities in industrial radiography, including specified delegations of authority and responsibility;

G. The applicant submits the qualifications of the individual(s) designated as the Radiation Safety Officer as described in RH-1802.d.;

H. The applicant who intends to collect leak test samples of sealed sources or exposure devices containing depleted uranium (DU) shielding has described the procedures for performing the sampling and the qualifications of the individual(s) authorized to do the sampling. If the applicant intends to analyze its own wipe samples, the application shall include a description of the procedures to be followed. The description shall include the:

i. Instrumentation to be used;

ii. Methods of performing the analysis; and

iii. Pertinent experience of the individual(s) who will analyze the wipe samples.

I. The applicant who intends to perform calibrations of survey instruments and/or alarming ratemeters describes methods to be used and the experience of the individual(s) who will perform the calibrations. All calibrations must be performed according to the procedures described and at the intervals prescribed in RH-1801.e.3. and RH-1802.f.7.D.

J. The applicant identifies and describes the location(s) of all field stations and permanent radiographic installations; and

K. The applicant identifies the locations(s) where all records required by this Part and other Sections of these Regulations will be maintained.

c. **Definitions**.

Access panel - Any barrier or panel which is designed to be removed or opened for maintenance or service purposes, requires tools to open and permits access to the interior of the cabinet.

ALARA (acronym for "as low as is reasonably achievable") - Making every reasonable effort to maintain exposures to radiation as far below the dose limits specified in Part C, "Permissible Doses, Levels, and Concentrations," of Section 3 as is practical, consistent with the purpose for which the licensed or registered activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvement in relation to benefits to the public health and safety, and other societal and socio-economic considerations, and in relation to utilization of nuclear energy, licensed materials, and x-ray equipment in the public interest.

Annual refresher safety training - A review conducted or provided by the licensee or registrant for its employees on radiation safety aspects of industrial radiography. The review may include, as appropriate, the results of internal inspections, new procedures or equipment, new or revised regulations, accidents or errors that have been observed, and should also provide opportunities for employees to ask safety questions.

Aperture - Any opening in the outside surface of the cabinet, other than a port, which remains open during generation of x-radiation.

Associated equipment - Equipment that is used in conjunction with a radiographic exposures device to make radiographic exposures that drives, guides, or comes in contact with the source, (e.g., guide tube, control tube, control (drive) cable, removable source stop, "J" tube and collimator when it is used as an exposure head.)

Becquerel (Bq) - One (1) disintegration per second.

Cabinet radiography - Industrial radiography conducted in an enclosed cabinet which is so shielded that every location on the exterior meets conditions for an unrestricted area as specified in RH-1208.

Cabinet x-ray system - An x-ray system with the x-ray tube installed in an enclosure (hereinafter termed "cabinet") which, independently of existing architectural structures except the floor on which it may be placed, is intended to contain at least that portion of a material being irradiated, provide radiation attenuation and exclude personnel from its interior during generation of x-radiation. Included are all x-ray systems designed primarily for the inspection of carry-on baggage at airline, railroad and bus terminals and in similar facilities. An x-ray tube used within a shielded part of a building or x-ray equipment which may temporarily or occasionally incorporate portable shielding is not considered a cabinet x-ray system.

Certified cabinet system - X-ray systems which are subject to regulations promulgated under Public Law 90-602, the Radiation Control for Health and Safety Act of 1968.

Certifying Entity - An independent certifying organization meeting the requirements in Schedule B of this Section or an Agreement State meeting the requirements in Schedule B, Parts II and III.

Collimator - a radiation shield that is placed on the end of the guide tube or directly onto a radiographic exposure device to restrict the size of the radiation beam when the sealed source is cranked into position to make a radiographic exposure.

Control (drive) cable - The cable that is connected to the source assembly and used to drive the source to and from the exposure location.

Control drive mechanism - A device that enables the source assembly to be moved to and from the exposure device.

Control tube - A protective sheath for guiding the control cable. The control tube connects the control drive mechanism to the radiographic exposure device.

Door - Any barrier which is designed to be movable or opened for routine operations purposes, does not generally require tools to open and permits access to the interior of the cabinet. For the purposes of RH-1803.g.1.A. of this Section, inflexible hardware rigidly affixed to the door shall be considered part of the door.

Enclosed radiography - Industrial radiography conducted in an enclosed cabinet or room and includes cabinet radiography, cabinet x-ray systems and shielded room radiography.

Exposure head - A device that locates the gamma radiography sealed source in the selected working position. (An exposure head is also known as a source stop).

External surface - The outside surface of the cabinet x-ray system, including the high-voltage generator, doors, access panels, latches, control knobs and other permanently mounted hardware and including the plane across any aperture or port.

Field station - A facility where licensed material or registered x-ray equipment may be stored or used and from which equipment is dispatched.

Floor - The underside external surface of the cabinet.

Gray - The SI unit of absorbed dose. A gray is equal to an absorbed dose of one (1) Joule/kilogram. It is also equal to 100 rads.

Ground fault - An accidental electrical grounding of an electrical conductor.

Guide tube (Projection sheath) - A flexible or rigid tube (i.e., "J" tube) for guiding the source assembly and the attached control cable from the exposure device to the exposure head. The guide tube may also include the connections necessary for attachment to the exposure device and to the exposure head.

Hands-on experience - Experience in all of those areas considered to be directly involved in the radiography process.

Independent Certifying Organization - An independent organization that meets all the criteria of Schedule B to Section 3.

Industrial radiography (radiography) - An examination of the structure of materials by non-destructive methods, utilizing ionizing radiation to make radiographic images.

Lay-barge radiography - Industrial radiography performed on any water vessel used for laying pipe.

Offshore platform radiography – Industrial radiography performed from a platform over a body of water.

Permanent radiographic installation - An enclosed shielded room, cell, or vault, not located at a temporary jobsite, in which radiography is performed.

Port - Any opening in the outside surface of the cabinet which is designed to remain open, during generation of x-rays, for the purpose of conveying material to be irradiated into and out of the cabinet or for partial insertion for irradiation of an object whose dimensions do not permit complete insertion into the cabinet.

Practical examination - A demonstration through practical application of the safety rules and principles in industrial radiography including use of all appropriate equipment and procedures.

Primary beam - The x-radiation emitted directly from the target and passing through the window of the x-ray tube.

Radiation Safety Officer for industrial radiography - An individual with the responsibility for the overall radiation safety program on behalf of the licensee or registrant and who meets the requirements of RH-1802.d.

Radiographer - Any individual who performs or who, in attendance at the site where sources of radiation are being used, personally supervises industrial radiographic operations and who is responsible to the licensee or registrant for assuring compliance with the requirements of these Regulations and the conditions of registration or of a license.

Radiographer's assistant - Any individual who, under the direct supervision of a radiographer, uses radiographic exposure devices, sources of radiation, related handling tools, or radiation survey instrumentation in industrial radiography.

Radiographer certification - Written approval received from a certifying entity stating that an individual has satisfactorily met certain established radiation safety, testing, and experience criteria.

Radiographic exposure device - Any instrument containing a sealed source fastened or contained therein, in which the sealed source or shielding thereof may be moved or otherwise changed, from a shielded to unshielded position for purposes of making a radiographic exposure.

Radiographic operations - All activities associated with the presence of x-ray machines, accelerators, or radioactive sources in radiographic exposure devices, during use of the machine, accelerator, or device, or transport (except when being transported by a common or contract carrier), to include surveys to confirm the adequacy of boundaries, setting up equipment, and any activity inside restricted area boundaries. Transporting a radiation machine or accelerator is not considered a radiographic operation.

Radiography - See "industrial radiography."

Safety interlock - A device which is intended to prevent the generation of x-radiation when access by any part of the human body to the interior of the cabinet x-ray system through a door or access panel is possible.

Sealed source - Any radioactive material that is encased in a capsule designed to prevent leakage or escape of the radioactive material.

Shielded room radiography - Industrial radiography conducted in an enclosed room, the interior of which is not occupied during radiographic operations, which is so shielded that every location on the exterior meets the conditions for an unrestricted area as specified in RH-1208.

Shielded position - The location within the radiographic exposure device or source changer where the sealed source is secured and restricted from movement.

Sievert - The SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv = 100 rem).

Source Assembly - An assembly that consists of the sealed source and a connector that attaches the source to the control cable. The source assembly may also include a stop ball used to secure the source in the shielded position.

Source changer - A device designed and used for replacement of sealed sources in radiographic exposure devices, including those also used for transporting and storage of sealed sources.

S-tube - A tube through which the radioactive source travels when inside a radiographic exposure device.

Storage area - Any location, facility, or vehicle which is used to store, to transport, or to secure a radiographic exposure device, a storage container, or a sealed source when it is not in use and which is locked or has a physical barrier to prevent accidental exposure, tampering with, or unauthorized removal of the device, container, or source.

Storage container - A container in which sealed sources are secured and stored.

Temporary job site - A location where radiographic operations are conducted and where licensed material may be stored other than the location(s) of use authorized on the license or registration.

Transport container - A package that is designed to provide radiation safety and security when sealed sources are transported and meets all applicable requirements of the U.S. Department of Transportation.

Underwater radiography - Industrial radiography performed when the radiographic exposure device and/or related equipment are beneath the surface of the water.

X-ray system - An assemblage of components for the controlled generation of x-rays.

X-ray tube - Any electron tube which is designed for the conversion of electrical energy into x-ray energy.

d. **Recordkeeping Requirements**.

1. **Records of the specific license for industrial radiography**.

Each licensee shall maintain a copy of its license, license conditions, documents incorporated by reference, and amendments to each of these items until superseded by new documents approved by the Department or until the Department terminates the license.

2. **Records of receipt and transfer of sealed sources**.

A Each licensee shall maintain records showing the receipts and transfers of sealed sources and devices using depleted uranium (DU) for shielding and retain each record for three (3) years after it is made.

B These records must include the date, the name of the individual making the record, radionuclide, number of curies (becquerels) or mass (for depleted uranium (DU)) and manufacturer, model, and serial number of each sealed source and/or device, as appropriate.

3. **Records of radiation survey instruments**.

Each licensee or registrant shall maintain records of the calibrations of its radiation survey instruments that are required in RH-1801.e. and retain each record for three (3) years after it is made.

4. **Records of leak testing of sealed sources and devices containing depleted uranium (DU).**

Each licensee shall maintain records of leak test results for sealed sources and for devices containing depleted uranium (DU). The results must be stated in units of microcuries (bequerels). The licensee shall retain each record for three (3) years after it is made or until the source in storage is removed.

5. **Records of quarterly inventory**.

A. Each licensee shall maintain records of the quarterly inventory of sealed sources and of devices containing depleted uranium (DU) as required by RH-1801.g. and retain each record for three (3) years after it is made.

B. The record must include the date of the inventory, name of the individual conducting the inventory, radionuclide, number of curies (becquerels) or mass (for DU) in each device, location of sealed source and/or devices, and manufacturer, model, and serial number of each sealed source and/or device, as appropriate.

6. **Records of utilization logs**.

A Each licensee or registrant shall maintain utilization logs showing for each sealed source or x-ray unit the following information:

i A description, including the make, model, and serial number of the radiographic exposure device or transport or storage container in which the sealed source or x-ray tube is located;

ii The identity and signature of the radiographer to whom assigned; and

iii The plant or site where used and dates of use, including the dates removed and returned to storage.

B. The licensee or registrant shall retain the logs required by RH-1800.d.6.A.for three (3) years after the log is made.

7. **Records of inspection and maintenance of radiographic exposure devices, transport and storage containers, associated equipment, source changers, and survey instruments**.

A. Each licensee or registrant shall maintain records specified in RH-1801.i. of equipment problems found in daily checks and quarterly inspections of radiographic exposure devices, transport and storage containers, associated equipment, source changers, and survey instruments and retain each record for three (3) years after it is made.

B. The record must include the date of the check or inspection, name of the inspector, equipment involved, any problems found, and what repair and/or maintenance, if any, was done.

8. **Records of alarm system and entrance control checks at permanent radiographic installation**.

Each licensee or registrant shall maintain records of alarm system and entrance control device tests required under RH-1801.j. and retain each record for three (3) years after it is made.

9. **Records of training and certification**.

Each licensee or registrant shall maintain the following records (of training and certification) for three (3) years after the record is made:

A. Records of training of each radiographer and each radiographer's assistant. The record must include radiographer certification documents and verification of certification status, copies of written tests, dates of oral and practical examinations, and names of individuals conducting and receiving the oral and practical examinations; and

B. Records of annual refresher safety training and semi-annual inspections of job performance for each radiographer and each radiographer's assistant. The records must list the topics discussed during the refresher safety training, the dates the annual refresher safety training was conducted, and the names of the instructors and attendees. For inspections of job performance, the records must also include a list showing the items checked and any non-compliances observed by the Radiation Safety Officer (RSO).

10. **Copies of Operating and Emergency Procedures**.

Each licensee or registrant shall maintain a copy of current operating and emergency procedures until the Department terminates the license or registration. Superseded material must be retained for three (3) years after the change is made.

11. **Records of Personnel Monitoring Procedures**.

Each licensee or registrant shall maintain the following exposure recordsspecified in RH-1802.f.

A. Direct reading dosimeter readings and yearly operability checks required by RH-1802.f.2. and f.3. for three (3) years after the record is made.

B. Records of alarm ratemeter calibrations for three (3) years after the record is made.

C. Personnel dosimeter results received from the accredited NVLAP processor until the Department terminates the license or registration.

D. Records of estimates of exposures as a result of off-scale personal direct reading dosimeters, or lost or damaged personnel dosimeters, until the Department terminates the license or registration.

12. **Records of Radiation Surveys**.

Each licensee or registrant shall maintain a record of each exposure device survey conducted before the device is placed in storage as specified in RH-1803.c.3. if that survey is the last one performed in the workday. Each record must be maintained for three (3) years after it is made.

13. **Form of Records**.

Each record required by RH-1800.d. must be legible throughout the specified retention period. The record may 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 reproducing a clear copy throughout 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, and specifications, must include all pertinent information, such as stamps, initials, and signatures. The licensee or registrant shall maintain adequate safeguards against tampering with and loss of records.

14. **Location of documents and records**.

A. Each licensee or registrant shall maintain copies of records required by RH-1800.d. and other applicable regulations at the location specified in the licensee's license application.

B. Each licensee or registrant shall also maintain copies of the following documents and records sufficient to demonstrate compliance at each applicable field station and each temporary jobsite:

i. The license or certificate of registration authorizing the use of licensed material or x-ray equipment;

ii. A current copy of the Arkansas State Board of Health Rules and Regulations for Control of Sources of Ionizing Radiation.

iii. Utilization records for each radiographic exposure device dispatched from that location as required by RH-1800.d.6.

iv. Records of equipment problems identified in daily checks of equipment as required by RH-1800.d.7.

v. Records of alarm system and entrance control checks as required by RH-1801.j., if applicable.

vi. Records of direct reading dosimeters such as pocket dosimeter and/or electronic personal dosimeters readings as required by RH-1800.d.11.

vii. Operating and emergency procedures as required by RH-1802.e.

viii. Evidence of the latest calibration of the radiation survey instruments in use at the site as required by RH-1801.e.

ix. Evidence of the latest calibration of alarm rate-meters and operability checks of pocket dosimeters and/or electronic personal dosimeters as required by RH-1800.d.11.

x. Latest survey records as required by RH-1803.c.

xi. The shipping papers for the transportation of radioactive materials as required by RH-3005; and

xii. When operating under reciprocity pursuant to RH-750, a copy of the Agreement State or U.S. Nuclear Regulatory Commission license authorizing the use of licensed materials.

RH-1801. **Equipment Control**.

a. **Performance requirements for radiography equipment**.

Equipment used in industrial radiographic operations must meet the following minimum criteria:

1. Each radiographic exposure device, source assembly or sealed source, and all associated equipment must meet the requirements specified in American National Standards Institute N432-1980, "Radiological Safety for the Design and Construction of Apparatus for Gamma Radiography," (published as NBS Handbook 136, issued January 1981).

This publication may be purchased from the American National Standards Institute, Inc., 25 West 43rd Street, New York, New York 10036; Telephone: (212) 642-4900.

A copy of the document is available for inspection in the office of the Arkansas Department of Health, Radiation Control, 5800 West 10th Street, Suite 100, Little Rock, Arkansas 72204.

Engineering analysis may be submitted by an applicant or licensee to demonstrate the applicability of previously performed testing on similar individual radiography equipment components. Upon review, the Department may find this an acceptable alternative to actual testing of the component pursuant to the above referenced standard.

2. In addition to the requirements specified in RH-1801.a.1., the following requirements apply to radiographic exposure devices, source changers, source assemblies and sealed sources.

   A. The licensee shall ensure that each radiographic exposure device has attached to it by the user a durable, legible, clearly visible label bearing the:

      i. Chemical symbol and mass number of the radionuclide in the device;

      ii. Activity and the date on which this activity was last measured;

      iii. Model number (or product code) and serial number of the sealed source;

      iv. Manufacturer's identity of the sealed source; and

      v. Licensee's name, address, and telephone number.

   B. Radiographic exposure devices intended for use as Type B transport containers must meet the applicable requirements of Section 4, "Transportation of Radioactive Materials."

   C. Modification of radiographic exposure devices, source changers, source assemblies, and associated equipment is prohibited, unless the design of any replacement component, including the source holder, source assembly, controls or guide tubes would not compromise the design safety features of the system.

3. In addition to the requirements specified in RH-1801.a.1. and 2., the following requirements apply to radiographic exposure devices, source assemblies, and associated equipment that allow the source to be moved out of the device for radiographic operation or to source changers.

   A. The coupling between the source assembly and the control cable must be designed in such a manner that the source assembly will not become disconnected if cranked outside the guide tube. The coupling must be such that it cannot be unintentionally disconnected under normal and reasonably foreseeable abnormal conditions.

B. The device must automatically secure the source assembly when it is cranked back into the fully shielded position within the device. This securing system may only be released by means of a deliberate operation on the exposure device.

C. The outlet fittings, lock box, and drive cable fittings on each radiographic exposure device must be equipped with safety plugs or covers which must be installed during storage and transportation to protect the source assembly from water, mud, sand, or other foreign matter.

D. Each sealed source or source assembly must have attached to it or engraved on it, a durable, legible, visible label with the words "**DANGER – RADIOACTIVE**." The label must not interfere with the safe operation of the exposure device or associated equipment.

E. The guide tube must be able to withstand a crushing test that closely approximates the crushing forces that are likely to be encountered during use and be able to withstand a kinking resistance test that closely approximates the kinking forces likely to be encountered during use.

F. Guide tubes must be used when moving the source out of the device.

G. An exposure head or similar device designed to prevent the source assembly from passing out of the end of the guide tube must be attached to the outermost end of the guide tube during industrial radiographic operations.

H. The guide tube exposure head connection must be able to withstand the tensile test for control units specified in ANSI N432- 1980.

I. Source changers must provide a system for ensuring that the source will not be accidentally withdrawn from the changer when connecting or disconnecting the drive cable to or from a source assembly.

4. All radiographic exposure devices and associated equipment in use after January 10, 1996 must comply with the requirements of this section.

5. Notwithstanding RH-1801.a.1., equipment used in industrial radiographic operations need not comply with Section 8.9.2(c) of the Endurance Test in American National Standards Institute N432-1980, if the prototype equipment has been tested using a torque value representative of the torque that an individual using the radiography equipment can realistically exert on the lever or crankshaft of the drive mechanism.

b. **Limits on external radiation levels from storage containers and source changers**.

The maximum exposure rate limit for storage containers and source changers are 200 millirem (2 millisieverts) per hour at any exterior surface and ten (10) millirem (0.1 millisieverts) per hour at one (1) meter from any exterior surface with the sealed source in the shielded position.

c. **Locking of radiographic exposure devices, storage containers, and source changers**.

1. Each radiographic exposure device must have a lock or outer locked container designed to prevent unauthorized or accidental removal of the sealed source from its shielded position. The exposure device and/or its container must be kept locked (and if a keyed-lock, with the key removed at all times) when not under the direct surveillance of a radiographer or a radiographer's assistant except at permanent radiographic installations as in RH-1803.a. In addition, during radiographic operations, the sealed source assembly must be secured in the shielded position each time the source is returned to that position.

2. Each sealed source storage container and source changer must have a lock or outer locked container designed to prevent unauthorized or accidental removal of the sealed source from its shielded position. Storage containers and source changers must be kept locked (and if a keyed-lock, with the key removed at all times) when containing sealed sources except when under the direct surveillance of a radiographer or a radiographer's assistant.

3. The control panel of each radiation machine shall be equipped with a lock that will prevent the unauthorized use of an x-ray system or the accidental production of radiation. The radiation machine shall be kept locked and the key removed at all times except when under the direct visual surveillance of a radiographer or a radiographer's assistant.

d. **Storage precautions**.

1. Locked radiographic exposure devices, storage containers and radiation machines shall be physically secured to prevent tampering or removal by unauthorized personnel. The licensee shall store radioactive material in a manner which will minimize danger from explosion or fire.

2. Radiographic exposure devices, source changers, or transport containers that contain radioactive material may not be stored in residential locations. This rule does not apply to storage of radioactive material in a vehicle in transit for use at temporary job sites, if the licensee complies with RH-1801.d.3. and if the vehicle does not constitute a permanent storage location as described in RH-1801.d.4.

3. If a vehicle is to be used for storage of radioactive material, a vehicle survey shall be performed after securing radioactive material in the vehicle and before transport to ensure that radiation levels do not exceed the limits specified in RH-1208. at the exterior surface of the vehicle.

4. A storage or use location is permanent if radioactive material is stored or used at the location for more than ninety (90) days and any one (1) or more of the following applies to the location:

A. Telephone service is established by the licensee;

B. Industrial radiographic services are advertised for or from the location;

C. Industrial radiographic operations are conducted at other sites due to arrangements made from the location.

e. **Radiation survey instruments**.

1. The licensee or registrant shall keep sufficient calibrated and operable radiation survey instruments at each location where radioactive material or industrial radiographic x-ray equipment is present to make the radiation surveys as required by this Part and RH-1300.

2. Instrumentation required by this Part must be capable of measuring a range from two (2) milliroentgens (0.02 millisieverts) per hour through one (1) roentgen (0.01 sievert) per hour.

3. The licensee or registrant shall have each radiation survey instrument required in RH-1801.e.1.calibrated:

   A. At intervals not to exceed six (6) months and after each instrument servicing, except for battery changes;

   B. For linear scale instruments, at two (2) points located approximately one-third and two-thirds of full-scale; for logarithmic scale instruments, at midrange of each decade and at two (2) points on at least one decade; and for digital instruments, at three (3) points between 2 and 1000 millirems (0.02 and 10 millisieverts) per hour; and

   C. So that an accuracy within plus or minus twenty percent (± 20%) of the calibration source can be demonstrated at each point checked.

4. The licensee shall maintain records of these calibrations in accordance with RH-1800.d.3.

5. Each radiation survey instrument shall be checked with a radiation source at the beginning of each day of use and at the beginning of each work shift to ensure it is operating properly.

f. **Leak testing and replacement of sealed sources**.

1. The replacement of any sealed source fastened to or contained in a radiographic exposure device and leak testing of any sealed source must be performed only by persons specifically authorized to do so by the Department, the U.S. Nuclear Regulatory Commission, or an Agreement State.

2. The opening, repair, or modification of any sealed source must be performed only by persons specifically authorized to do so by the Department, the U.S. Nuclear Regulatory Commission, or an Agreement State.

3. **Testing and recordkeeping requirements**.

A. Each licensee who uses a sealed source shall have the source tested for leakage in accordance with RH-1212. and as prescribed in this Part. Tests for leakage must be performed at intervals not to exceed six (6) months. The leak testing of the source must be performed using a method approved by the Department, the U.S. Nuclear Regulatory Commission, or an Agreement State. The wipe sample should be taken from the nearest accessible point to the sealed source where contamination might accumulate. The wipe sample must be analyzed for radioactive contamination. The analysis must be capable of detecting the presence of 0.005 microcurie (185 Bq) of radioactive material on the test sample and must be performed by a person specifically authorized by the Department, or designee, the U.S. Nuclear Regulatory Commission, or an Agreement State to perform the analysis.

B. The licensee shall maintain records of the leak tests in accordance with RH-1800.d.4.

C. Unless a sealed source is accompanied by a certificate from the transferor that shows that it has been leak tested within six (6) months before the transfer, it may not be used by the licensee until tested for leakage. Sealed sources that are in storage and not in use do not require leak testing but must be tested before use or transfer to another person if the interval of storage exceeds six (6) months.

4. Any test conducted pursuant to the requirements of RH-1801.f. which reveals the presence of 0.005 microcurie (185 Bq) or more of removable radioactive material must be considered evidence that the sealed source is leaking. The licensee shall immediately withdraw the equipment involved from use and shall cause it to be decontaminated and repaired or disposed of in accordance with Regulations of the Department. A report must be filed with the Department within five (5) days of any test with results that exceed the threshold in this paragraph, describing the equipment involved, the test results, and the corrective action taken.

5. Each exposure device using depleted uranium (DU) shielding and an "S" tube configuration must be tested for DU contamination at intervals not to exceed twelve (12) months. The analysis must be capable of detecting the presence of 0.005 microcurie (185 Bq) of radioactive material on the test sample and must be performed by a person specifically authorized by the Department, the U.S. Nuclear Regulatory Commission, or an Agreement State to perform the analysis.

   Should such testing reveal the presence of 0.005 microcurie (185 Bq) or more of removable DU contamination, the exposure device must be removed from use until an evaluation of the wear on the S-tube has been made. Should the evaluation reveal that the S-tube is worn through, the device may not be used again. DU shielded devices do not have to be tested for DU contamination while in storage and not in use. Before using or transferring such a device however, the device must be tested for DU contamination if the interval of storage exceeds twelve (12) months. A record of the DU leak test must be made in accordance with RH-1800.d.4.

g. **Quarterly inventory**.

1. Each licensee shall conduct a quarterly physical inventory to account for all sealed sources and for devices containing depleted uranium (DU) received and possessed under this license.

2 The licensee shall maintain records of the quarterly inventory in accordance with RH-1800.d.5.

h. **Utilization logs**.

Each licensee or registrant shall maintain current logs, which shall be kept available for inspection by the Department, showing for each source of radiation the following information:

1. A description, including the make, model and serial number of each radiation machine, each radiographic exposure device or transport or storage container in which a sealed source is located, and each sealed source;

2. The identity and signature of the radiographer to whom assigned;

3. Locations where used and dates of use; and

4. The date(s) each source of radiation is removed from storage and returned to storage.

i. **Inspection and maintenance of radiographic exposure devices, transport and storage containers, associated equipment, source changers, and survey instruments**.

1. The licensee or registrant shall perform visual and operability checks on survey meters, radiographic exposure devices, transport and storage containers, associated equipment, source changers, and shutters on x-ray units before use on each day the equipment is used to ensure that the equipment is in good working condition, that the sources are adequately shielded, and that required labeling is present. Survey instrument operability must be performed using check sources or other appropriate means. If equipment problems are found, the equipment must be removed from service until repaired.

2. Each licensee or registrant shall have written procedures for:

A. Inspection and routine maintenance of radiographic exposure devices, source changers, associated equipment, transport and storage containers, and survey instruments at intervals not to exceed three (3) months or before the first use thereafter to ensure the proper functioning of components important to safety. Replacement components shall meet design specifications. If equipment problems are found, the equipment must be removed from service until repaired.

B. Inspection and maintenance necessary to maintain the Type B packaging used to transport radioactive materials. The inspection and maintenance program must include procedures to assure that Type B packages are shipped and maintained in accordance with the Certificate of Compliance or other approval.

C. Records of equipment problems and of any maintenance performed under RH-1801.i.1.and i.2. must be made in accordance with RH-1800.d.7.

j. **Permanent radiographic installations**.

1. Each entrance that is used for personnel access to the high radiation area in a permanent radiographic installation must have either:

   A. An entrance control of the type described in RH-1303.c.2.A. that reduces the radiation level upon entry into the area, or

   B. Both conspicuous visible and audible warning signals to warn of the presence of radiation. The visible signal must be activated by radiation whenever the source is exposed. The audible signal must be actuated when an attempt is made to enter the installation while the source is exposed.

2. The alarm system must be tested for proper operation with a radiation source each day before the installation is used for radiographic operations. The test must include a check of both the visible and audible signals. Entrance control devices that reduce the radiation level upon entry (designated in RH-1801.j.1.A.) must be tested monthly. If an entrance control device or an alarm is operating improperly, it must be immediately labeled as defective and repaired within seven (7) calendar days.

   The facility may continue to be used during this seven (7) day period, provided the licensee or registrant implements the continuous surveillance requirements of RH-1803.a. and uses an alarming ratemeter. Test records for entrance controls and audible and visual alarm must be maintained in accordance with RH-1800.d.8.

k. **Notifications**.

1. In addition to the reporting requirements specified in RH-601. and under other Sections, each licensee or registrant shall provide a written report to the Arkansas Department of Health, Radiation Control Section, 4815 West Markham Street, Slot 30, Little Rock, Arkansas, 72205-3867 within thirty (30) days of the occurrence of any of the following incidents involving radiographic equipment:

   A. Unintentional disconnection of the source assembly from the control cable.

B. Inability to retract the source assembly to its fully shielded position and secure it in this position.

C. Failure of any component (critical to safe operation of the device) to properly perform its intended function.

D. An indicator on a radiation machine fails to show that radiation is being produced, an exposure switch fails to terminate production of radiation when turned to the "**OFF**" position, or a safety interlock fails to terminate x-ray production.

2. The licensee or registrant shall include the following information in each report submitted under RH-1801.k.1. and in each report of overexposure submitted under RH-1504. which involves failure of safety components of radiography equipment:

A. A description of the equipment problem.

B. Cause of each incident, if known.

C. Name of the manufacturer and model number of equipment involved in the incident.

D. Place, time, and date of the incident.

E. Actions taken to establish normal operations.

F. Corrective actions taken or planned to prevent recurrence.

G. Qualifications of personnel involved in the incident.

3. Any licensee or registrant conducting radiographic operations or storing radioactive material at any location not listed on the license or registration for a period in excess of 180 days in a calendar year, shall notify the Department prior to exceeding the 180 days.

RH-1801. (Cont'd)

l. **Labeling, storage, and transportation**.

1. The licensee may not use a source changer or a container to store radioactive material unless the source changer or the storage container has securely attached to it a durable, legible, and clearly visible label bearing the standard trefoil radiation caution symbol in conventional colors, i.e., magenta, purple or black on a yellow background having a minimum diameter of 25 mm, and the wording

"**CAUTION**,*
RADIOACTIVE MATERIAL,
NOTIFY CIVIL AUTHORITIES [or name of company]."

***or DANGER**

2. The licensee may not transport licensed material unless the material is packaged, and the package is labeled, marked, and accompanied with appropriate shipping papers in accordance with regulations set forth in Section 4, "Transportation of Radioactive Materials."

3. Locked radiographic exposure devices, storage containers, source changers and radiation machines must be physically secured to prevent tampering or removal by unauthorized personnel. The licensee shall store radioactive material in a manner which will minimize danger from explosion or fire.

4. The licensee shall lock and physically secure the transport package containing radioactive material in the transport vehicle to prevent accidental loss, tampering, or unauthorized removal of the radioactive material from the vehicle.

RH-1802. **Personnel Radiation Safety Requirements for Radiographers and Radiographer's Assistants**.

a. **Conducting industrial radiographic operations**.

1. Whenever radiography is performed at a location other than a permanent radiographic installation, the radiographer must be accompanied by at least one other qualified radiographer or an individual who has at a minimum met the requirements of RH-1802.b.3. The additional qualified individual shall observe the operations and be capable of providing immediate assistance to prevent unauthorized entry. Radiography may not be performed if only one (1) qualified individual is present.

2. All radiographic operations conducted at locations of use authorized on the license or on the x-ray registration must be conducted in a permanent radiographic installation, unless specifically authorized by the Department.

3. A licensee or registrant may conduct lay-barge or underwater radiography only if the procedures have been approved by the Department, by an Agreement State, or by the U.S. Nuclear Regulatory Commission.

b. **Training**.

1. The licensee or registrant may not permit any individual to act as a radiographer until the individual has received training in RH-1804., in addition to a minimum of two (2) months of on-the-job training under the supervision of a radiographer, and is certified through a radiographer certification program by a certifying entity in accordance with the criteria specified in Schedule B to Section 3.

2. In addition, the licensee or registrant may not permit any individual to act as a radiographer until the individual:

   A. Has received copies of and instructions in the requirements described in this Part; RH-107.; in the applicable sections of Section 3, "Standards for Protection Against Radiation," (including its Part N, "Notices, Instructions, and Reports to Workers; Inspections"); in applicable Department of Transportation (DOT) regulations as referenced in Section 4 of these Regulations and the U.S. Nuclear Regulatory Commission's (NRC) 10 CFR Part 71; in the Department license(s) under which the radiographer will perform industrial radiography; and the licensee's or registrant's operating and emergency procedures;

   B. Has demonstrated understanding of the licensee's license and the licensee's or registrant's operating and emergency procedures by successful completion of a written or oral examination covering this material.

   C. Has received training in the use of the licensee's or registrant's radiographic exposure devices, sealed sources, in the daily inspection of devices and associated equipment, and in the use of radiation survey instruments.

   D. Has demonstrated understanding of the use of radiographic exposure devices, sources, survey instruments and associated equipment described above in RH-1802.b.2.A. and RH-1802.b.2.C. by the successful completion of a practical examination covering this material.

3. The licensee or registrant may not permit any individual to act as a radiographer's assistant until the individual:

   A. Has received copies of and instructions in the requirements described in this Part; RH-107.; in the applicable sections of Section 3, "Standards for Protection Against Radiation," (including its Part N, "Notices, Instructions, and Reports to Workers; Inspections"); in applicable Department of Transportation (DOT) regulations as referenced in Section 4 of these Regulations and the U.S. Nuclear Regulatory Commission's (NRC) 10 CFR Part 71; in the Department license(s) under which the radiographer's assistant will perform industrial radiography; and the licensee's or registrant's operating and emergency procedures;

B. Has developed competence in the use, under the personal supervision of the radiographer, radiographic exposure devices, sealed sources, associated equipment, and radiation survey instruments that the assistant will use; and

C. Has demonstrated understanding of the instructions provided above in RH-1802.b.3.A. by the successful completion of a written test on the subjects covered and has demonstrated competence in the use of hardware described in RH-1802.b.3.B. by the successful completion of a practical examination on the use of such hardware.

4. The licensee or registrant shall provide annual refresher safety training for each radiographer and radiographer's assistant at intervals not to exceed twelve (12) months.

5. Except as provided in RH-1802.b.5.D., the RSO or designee shall conduct an inspection program of the job performance of each radiographer and radiographer's assistant to ensure that the Department's regulations, license requirements, and the applicant's operating and emergency procedures are followed. The inspection program must:

A. Include observation of the performance of each radiographer and radiographer's assistant during an actual industrial radiographic operation, at intervals not to exceed six (6) months; and

B. Provide that, if a radiographer or radiographer's assistant has not participated in an industrial radiographic operation for more than six (6) months since the last inspection, the radiographer must demonstrate knowledge of the training requirements of RH-1802.b.2.C., and the radiographer's assistant must re-demonstrate knowledge of the training requirements of RH-1802.b.3.B., by a practical examination before these individuals can next participate in a radiographic operation.

C. The Department may consider alternatives in those situations where the individual serves as both radiographer and RSO.

D. In those operations where a single individual serves as both radiographer and RSO, and performs all radiography operations, an inspection program is not required.

6. The licensee or registrant shall maintain records of the above training to include certification documents, written and practical examinations, refresher safety training and inspections of job performance in accordance with RH-1800.d.9.

7. The licensee or registrant shall include the subjects detailed in RH-1804.

8. Records of radiographer certification maintained in accordance with RH-1800.d.9.A. provide appropriate affirmation of certification requirements specified in RH-1802.b.1.

c. **Radiographer certificate card confiscation**.

The Department may confiscate any radiographer's certification card should there be serious health and safety violations relating to the Regulations, license conditions, and/or licensee operating and emergency procedures. The radiographer will be restricted from conducting radiographic operations within the State of Arkansas.

1. Following the confiscation of the radiographer's certification card, the conduct of any radiographic operations by this radiographer within the State of Arkansas shall be deemed deliberate misconduct as detailed in RH-107.

2. The Department shall notify the licensee's management and the Certifying Entity of the certification card confiscation and the restrictions placed on the radiographer.

3. The Department shall return the Certification Card when the radiographer has been satisfactorily retrained and/or recertified by a Certifying Entity.

d. **Radiation Safety Officer for industrial radiography**.

The Radiation Safety Officer (RSO) shall ensure that radiation safety activities are being performed in accordance with approved procedures and regulatory requirements in the daily operation of the licensee's or registrant's program.

1. The minimum qualifications, training, and experience of Radiation Safety Officers (RSO) for industrial radiography are as follows:

   A. Completion of the training and testing requirements of RH-1802.b.1.;

   B. 2000 hours of hands-on experience as a qualified radiographer in industrial radiographic operations; and

   C. Formal training in the establishment and maintenance of a radiation protection program.

2. The Department will consider alternatives when the RSO has appropriate training and/or experience in the field of ionizing radiation, and in addition, has adequate formal training with respect to the establishment and maintenance of a radiation safety protection program.

3. The specific duties and authorities of the RSO include, but are not limited to:

   A Establishing and overseeing all operating, emergency, and ALARA procedures as required by this Section, "Standards for Protection Against Radiation," and reviewing them regularly to ensure that the procedures in use conform to current Section 3 procedures, conform to other Department regulations, and to the license conditions.

   B. Overseeing and approving all phases of the training program for radiographic personnel, ensuring that appropriate and effective radiation protection practices are taught;

   C. Ensuring that required radiation surveys and leak tests are performed and documented in accordance with the regulations, including any corrective measures when levels of radiation exceed established limits;

D. Ensuring that personnel monitoring devices are calibrated and used properly by occupationally exposed personnel, that records are kept of the monitoring results, and that timely notifications are made as required by RH-1504.; and

E. Ensuring that operations are conducted safely and to assume control for instituting corrective actions including stopping of operations when necessary.

e. **Operating and emergency procedures**.

1. The licensee's or registrant's operating and emergency procedures must include as a minimum, instructions in the following:

A. Appropriate handling and use of licensed sealed sources, radiographic exposure devices, and x-ray equipment (if used) so that no person is likely to be exposed to radiation doses in excess of the limits established in Part C of this Section;

B. Methods and occasions for conducting radiation surveys;

C. Methods for posting and controlling access to radiographic areas;

D. Methods and occasions for locking and securing radiographic exposure devices, transport and storage containers and sealed sources;

E. Personnel monitoring and the use of personnel monitoring equipment;

F. Transporting sealed sources to field locations, including packing of radiographic exposure devices and storage containers in the vehicles, placarding of vehicles when needed, and control of the sealed sources during transportation.

G. The inspection, maintenance, and operability checks of radiographic exposure devices, survey instruments, transport containers, and storage containers;

H. Steps that must be taken immediately by radiography personnel in the event a pocket dosimeter is found to be off-scale or an alarm ratemeter alarms unexpectedly.

I. The procedure for notifying proper persons in the event of an accident;

J. Minimizing exposure of persons in the event of an accident;

K. Source recovery procedure if licensee will perform source recovery;

L. Maintenance of records.

2. The licensee or registrant shall maintain copies of current operating and emergency procedures in accordance with RH-1800.d.10.and RH-1800.d.14.

f. **Personnel monitoring**.

1. A licensee or registrant may not permit any individual to act as a radiographer or a radiographer's assistant unless, at all times during radiographic operations, each individual wears, on the trunk of the body, a combination of a direct reading pocket dosimeter, an operable alarm ratemeter, and a personnel dosimeter that is processed and evaluated by an accredited National Voluntary Laboratory Accreditation Program (NVLAP) processor. At permanent radiography installations where other appropriate alarming or warning devices are in routine use, the wearing of an alarming ratemeter is not required.

A. Pocket dosimeters shall have a range from zero to 200 millirems (2 millisieverts) and must be recharged at the start of each shift. Electronic personal dosimeters may only be used in place of ion-chamber pocket dosimeters.

B. Each personnel dosimeter must be assigned to and worn by only one (1) individual.

C. Personnel dosimeters that are processed and evaluated by the accredited National Voluntary Laboratory Accreditation Program (NVLAP) processor must be replaced at periods not to exceed one (1) month.

D. After replacement, each personnel dosimeter must be processed as soon as possible.

2. Direct reading dosimeters such as pocket dosimeters or electronic personal dosimeters, must be read and the exposures recorded at the beginning and end of each shift, and records must be maintained in accordance with RH-1800.d.11.

3. Pocket dosimeters, or electronic personal dosimeters, must be checked at periods not to exceed twelve (12) months for correct response to radiation, and records must be maintained in accordance with RH-1800.d.11. Acceptable dosimeters shall be read within plus or minus twenty percent (± 20%) of the true radiation exposure.

4. If an individual's pocket dosimeter is found to be off-scale, or if his or her electronic personal dosimeter reads greater than 200 millirems (2 millisieverts), and the possibility of radiation exposure cannot be ruled out as the cause, the individual's personnel dosimeter must be sent for processing within twenty-four (24) hours. In addition, the individual may not resume work associated with licensed material or other sources of radiation until a determination of the individual's radiation exposure had been made. This determination must be made by the RSO or the RSO's designee. The results of this determination must be included in the records maintained in accordance with RH-1800.d.11.

5. Dosimetry reports received from the accredited NVLAP personnel dosimeter processor must be retained in accordance with RH-1800.d.11.

6. If a personnel dosimeter that is required in RH-1802.f. is lost or damaged, the worker shall cease work immediately until a replacement personnel dosimeter meeting the requirements in RH-1802.f. is provided and the exposure is calculated for the time period from issuance to loss or damage of the personnel dosimeter. The results of the calculated exposure and the time period for which the personnel dosimeter was lost or damaged must be included in the records maintained in accordance with RH-1800.d.11.

7. Each alarm ratemeter shall:

   A. Be checked to ensure that the alarm functions properly (sounds) before using at the start of each shift;

   B. Be set to give an alarm signal at a preset dose rate of 500 mrem/hr (5 mSv/hr); with an accuracy rate of plus or minus twenty percent (± 20%) of the true radiation dose rate;

   C. Require special means to change the preset alarm function; and

   D. Be calibrated at periods not to exceed twelve (12) months for correct response to radiation. The licensee or registrant shall maintain records of alarm ratemeter calibrations in accordance with RH-1800.d.11.

g. **Reciprocity of a radiographer certification**.

1. Reciprocal recognition by the Department of an individual radiographer certification will be granted provided that:

   A. The individual holds a valid certification in the appropriate category issued by a certifying entity, as defined in RH-1800.c.;

   B. The requirements and procedures of the certifying entity issuing the certification affords the same or comparable certification standards as those afforded by RH-1802.b.1.; and

   C. The individual presents the certification to the Department prior to entry into the State.

2. The Department may withdraw, limit, or qualify its acceptance of any individual radiographer certification based on enforcement actions with the Department, another Agreement State, or the Nuclear Regulatory Commission or sanctions by an independent certifying entity in order to prevent undue hazard to public health and safety or property.

RH-1802.g. (Cont'd)

3. Certified individuals who are granted reciprocity by the Department shall maintain the certification upon which the reciprocal recognition was granted, or prior to the expiration of such certification, shall meet the requirements of RH-1802.b.1.

RH-1803. **Precautionary Procedures in Radiographic Operations**.

a. **Surveillance**.

During each radiographic operation, the radiographer or the other individual present as required in RH-1802.a. shall maintain continuous, direct visual surveillance of the operation to protect against unauthorized entry into a high radiation area, as defined in Section 3, Part D, RH-1303.c., except at permanent radiographic installations where all entryways are locked and the requirements of RH-1801.j. are met.

b. **Posting.**

All areas in which industrial radiography is being performed must be conspicuously posted as required by RH-1303.b.1. and b.2. Exceptions listed in RH-1304. do not apply to industrial radiographic operations.

c. **Radiation surveys**.

The licensee or registrant shall:

1. Conduct surveys with a calibrated and operable radiation survey instrument that meets the requirements of RH-1801.e.

2. Using a survey instrument meeting the requirement of RH-1803.c.1. above, conduct a survey of the radiographic exposure device and the guide tube after each exposure when approaching the device or the guide tube. The survey must determine that the sealed source has been returned to its shielded position before exchanging films, repositioning the exposure head, or dismantling equipment. Radiation machines shall be surveyed after each exposure to determine that the machine is off.

3. Conduct a survey of the radiographic exposure device with a calibrated radiation survey instrument any time the source is exchanged and whenever a radiographic exposure device is placed in a storage area (as defined in RH-1800.c.), to ensure that the sealed source is in its shielded position.

4. Maintain records in accordance with RH-1800.d.12.

d. **Supervision of radiographer's assistants**.

Whenever a radiographer's assistant uses radiographic exposure devices, associated equipment or sealed sources or conducts radiation surveys required by RH-1803.c.2. to determine that the sealed source has returned to the shielded position after an exposure, the assistant shall be under the personal supervision of a radiographer. The personal supervision shall include:

1. The radiographer's physical presence at the site where the sealed sources are being used,

2. The availability of the radiographer to give immediate assistance if required, and

3. The radiographer's direct observation of the assistant's performance of the operations referred to in this section.

e. **Records required at temporary job sites**.

Each licensee or registrant conducting industrial radiography at temporary job sites shall have the following records available at that site for inspection by the Department:

1. Current copy of appropriate license, certificate of registration or an equivalent document.

2. Operating and emergency procedures.

3. Applicable regulations.

4. Survey records required pursuant to RH-1803.c. for the period of operation at the site.

5. Daily pocket dosimeter records for the period of operation at the site.

6. The latest instrument calibration and leak test record for specific devices in use at the site.

f. **Specific requirements for radiographic personnel performing industrial radiography**.

1. At a job site, the following shall be supplied by the licensee or registrant:

A. At least one operable, calibrated survey instrument;

B. A current whole body personnel dosimeter that is processed and evaluated by an accredited National Voluntary Laboratory Accreditation Program (NVLAP) processor for each individual performing radiographic operations;

C. An operable, calibrated pocket dosimeter with a range of zero to 200 milliroentgens for each individual performing radiographic operations;

D. An operable, calibrated alarming ratemeter for each individual performing radiographic operations; and

E. The appropriate barrier ropes and signs.

2. Each radiographer shall have available at the job site a valid certification ID card issued by a certifying entity.

3. Industrial radiographic operations shall not be performed if any of the items in paragraphs f.1. and f.2. of this section are not available at the job site or are inoperable.

4. During an inspection by the Department, the Department inspector may terminate an operation if any of the items in paragraphs f.1. and f.2. of this section are not available and operable, or if the required number of radiographic personnel are not present. Operations shall not be resumed until such conditions are met.

g. **Special requirements and exemptions for enclosed radiography**.

1. **Cabinet x-ray systems**.

A. **Emission limit**.

i. Radiation emitted from the cabinet x-ray system shall not exceed an exposure of 0.5 milliroentgen in one hour at any point five (5) centimeters outside the external surface.

ii. Compliance with the exposure limit in RH-1803.g.1.A.i. of this section shall be determined by measurements averaged over a cross-sectional area of 10 (ten) square centimeters with no linear dimension greater than five (5) centimeters, with the cabinet x-ray system operated at those combinations of x-ray tube potential, current, beam orientation and conditions of scatter radiation which produce the maximum x-ray exposure at the external surface and with the door(s) and access panel(s) fully closed as well as fixed at any other position(s) which will allow the generation of x-radiation.

B. **Floors**.

A cabinet x-ray system shall have a permanent floor. Any support surface to which a cabinet x-ray system is permanently affixed may be deemed the floor of the system.

C. **Ports and apertures**.

i. The insertion of any part of the human body through any port into the primary beam shall not be possible.

ii. The insertion of any part of the human body through any aperture shall not be possible.

D. **Safety interlocks**.

i. Each door of a cabinet x-ray system shall have a minimum of two (2) safety interlocks. One (1), but not both, of the required interlocks shall be such that door opening results in physical disconnection of the energy supply circuit to the high-voltage generator, and such disconnection shall not be dependent upon any moving part other than the door.

ii. Each access panel shall have at least one safety interlock.

iii. Following interruption of x-ray generation by the functioning of any safety interlock, use of a control provided in accordance with RH-1803.g.1.F. shall be necessary for resumption of x-ray generation.

iv. Failure of any single component of the cabinet x-ray system shall not cause failure of more than one (1) required safety interlock.

E. **Ground fault**.

A ground fault shall not result in the generation of x-rays.

F. **Controls and indicators for all cabinet x-ray systems**.

For all systems to which this section is applicable, there shall be provided:

i. A key-actuated control to insure that x-ray generation is not possible with the key removed.

ii. A control or controls to initiate and terminate the generation of x-rays other than by functioning of a safety interlock or the main power control.

iii. Two independent means which indicate when and only when x-rays are being generated, unless the x-ray generation period is less than one-half second, in which case the indicators shall be activated for one-half second, and which are discernible from any point at which initiation of x-ray generation is possible. Failure of a single component of the cabinet x-ray system shall not cause failure of both indicators to perform their intended function. One, but not both, of the indicators required by this subdivision may be a milliammeter labeled to indicate x-ray tube current. All other indicators shall be legibly labeled "**X-RAY ON**."

iv. Additional means other than milliammeters which indicate when and only when x-rays are being generated, unless the x-ray generation period is less than one-half second, in which case the indicators shall be activated for one-half second, as needed to ensure that at least one indicator is visible from each door, access panel and port and is legibly labeled "**X-RAY ON**."

G. **Additional controls and indicators for cabinet x-ray systems designed to admit humans**.

For cabinet x-ray systems designed to admit humans, there shall also be provided:

i. Compliance with all applicable requirements of this Part and RH-1208. of these Regulations. If such a system is a certified cabinet x-ray system, it shall comply with all applicable requirements of this Part and 21 CFR 1020.40.

ii. Evaluation at intervals not to exceed one (1) year to assure compliance with the applicable requirements as specified in RH-1803.g.1.A. Records of these evaluations shall be maintained for inspection by the Department for a period of (5) years after the evaluation.

iii. A control within the cabinet for preventing and terminating x-ray generation, which cannot be reset, over-ridden or bypassed from the outside of the cabinet.

iv. No means by which x-ray generation can be initiated from within the cabinet.

v. Audible and visible warning signals within the cabinet which are actuated for at least ten (10) seconds immediately prior to the first initiation of x-ray generation after closing any door designed to admit humans. Failure of any single component of the cabinet x-ray system shall not cause failure of both the audible and visible warning signals.

vi. A visible warning signal within the cabinet which remains actuated when and only when x-rays are being generated, unless the x-ray generation period is less than one-half second, in which case the indicators shall be activated for one-half second.

vii. Signs indicating the meaning of the warning signals provided pursuant to RH-1803.g.1.G.v. and vi. and containing instructions for the use of the control provided pursuant to RH-1803.g.1.G.iii. These signs shall be legible, accessible to view and illuminated when the main power control is in the "**on**" position.

H. **Warning labels**.

i. There shall be permanently affixed or inscribed on the cabinet x-ray system at the location of any controls which can be used to initiate x-ray generation, a clearly legible and visible label bearing the statement:

CAUTION:
X-RAYS PRODUCED WHEN ENERGIZED

ii. There shall be permanently affixed or inscribed on the cabinet x-ray system at the location of any controls which can be used to initiate x-ray generation, a clearly legible and visible label bearing the statement:

CAUTION:
DO NOT INSERT ANY PART OF THE BODY
WHEN SYSTEM IS ENERGIZED--
X-RAY HAZARD

I. **Instructions**.

i. Manufacturers of cabinet x-ray systems shall provide for purchasers and to others upon request at a cost not to exceed the cost of preparation and distribution, manuals and instructions which shall include at least the following technical and safety information: Potential, current and duty cycle ratings of the x-ray generation equipment; adequate instructions concerning any radiological safety procedures and precautions which may be necessary because of unique features of the system; and a schedule of maintenance necessary to keep the system in compliance with this section.

ii. Manufacturers of cabinet x-ray systems which are intended to be assembled or installed by the purchaser, shall provide instructions for assembly, installation, adjustment and testing of the cabinet x-ray system adequate to assure the system is in compliance with applicable provisions of this section when assembled, installed, adjusted and tested as directed.

J. **Additional requirements for x-ray baggage inspection systems**.

X-ray systems designed primarily for the inspection of carry-on baggage at airline, railroad and bus terminals and at similar facilities, shall be provided with means, pursuant to RH-1803.g.1.J.i. and ii., to insure operator presence at the control area in a position which permits surveillance of the ports and doors during generation of x-radiation.

i. During an exposure or preset succession of exposures of one-half second or greater duration, the means provided shall enable the operator to terminate the exposure or preset succession of exposures at any time.

ii. During an exposure or preset succession of exposures of less than one-half second or greater duration, the means provided may allow completion of the exposure in progress but shall enable the operator to prevent additional exposures.

2. **Cabinet Radiography**.

Cabinet radiography units are exempt from other requirements of this Part; however,

A. No licensee or registrant shall permit any individual to operate a cabinet radiography unit until such individual has received a copy of, and instruction in, and has demonstrated an understanding of operating procedures for the unit, and has demonstrated competence in its use.

B. A cabinet radiography unit shall not be operated until a physical radiation survey of the unit and areas adjacent to the unit has been performed. The licensee or registrant shall perform the survey with a properly calibrated instrument as described in RH-1803.c. to determine conformance with RH-1200.

C. The registrant shall perform an evaluation, at intervals not to exceed one (1) year, to determine conformance with Part C of Section 3. If such a system is a certified cabinet x-ray system, it shall be evaluated at intervals not to exceed (1) year to determine conformance with 21 CFR 1020.40. Records of these evaluations shall be maintained for inspection by the Department for a period of five (5) years after the evaluation.

D. The operating personnel must be provided with either a film badge or a thermoluminescent dosimeter, and reports of the results must be maintained for inspection by the Department.

E. Tests for proper operation of high radiation control devices or alarm systems must be conducted and recorded in accordance with RH-1801.i.

3. **Shielded room radiography**.

Shielded room radiography shall comply with all applicable requirements of this Part.

4. Certified cabinet x-ray systems shall be maintained in compliance with 21 CFR 1020.40 unless prior approval has been granted by the Department pursuant to RH-55 of these Regulations.

g. **Prohibitions**.

Industrial radiography performed with a sealed source which is not fastened to or contained in a radiographic exposure device (fish pole technique) is prohibited unless specifically authorized in a license issued by the Department.

RH-1804. **Subjects to be Covered During the Instruction of Radiographers**.

a. **Fundamentals of radiation safety**.

1. Characteristics of gamma and/or x-ray radiation.

2. Units of radiation dose and quantity of radioactivity.

3. Hazards of exposure to radiation.

4. Levels of radiation from sources of radiation.

5. Methods of controlling radiation dose.

A. Time.

B. Distance.

C. Shielding.

b. **Radiation detection instruments**.

1. Use of radiation survey instruments.

A. Operation.

B. Calibration.

C. Limitations.

2. Survey techniques.

3. Use of personnel monitoring equipment.

A. Film badges.

B. Thermoluminescent dosimeters (TLDs).

C. Optically Stimulated Luminescent dosimeters.

D. Pocket dosimeters.

E. Alarm ratemeters.

c. **Equipment to be used**.

1. Operation and control of radiographic exposure equipment, remote handling equipment, and storage containers, including pictures or models of source assemblies (pigtails).

2. Storage, control, and disposal of licensed material.

3. Inspection and maintenance of equipment.

RH-1804.c. (Cont'd)

4. Operation and control of x-ray equipment if applicable.

5. Collimators.

d. The requirements of pertinent Federal and State regulations.

e. The licensee's or registrant's written operating and emergency procedures.

f. Case histories of accidents in radiography.

RH-1805.- RH-1899. Reserved.

SCHEDULE B TO SECTION 3

RADIOGRAPHIC CERTIFICATION

I. **Requirements for an Independent Certifying Organization**.

An independent certifying organization shall:

1. Be an organization such as a society or association, whose members participate in, or have an interest in, the fields of industrial radiography;

2. Make its membership available to the general public nationwide that is not restricted because of race, color, religion, sex, age, national origin or disability;

3. Have a certification program open to nonmembers, as well as members;

4. Be an incorporated, nationally recognized organization, that is involved in setting national standards of practice within its fields of expertise;

5. Have an adequate staff, a viable system for financing its operations, and a policy-and-decision-making review board;

6. Have a set of written organizational by-laws and policies that provide adequate assurance of lack of conflict of interest and a system for monitoring and enforcing those by-laws and policies;

7. Have a committee, whose members can carry out their responsibilities impartially, to review and approve the certification guidelines and procedures, and to advise the organization's staff in implementing the certification program;

8. Have a committee, whose members can carry out their responsibilities impartially, to review complaints against certified individuals and to determine appropriate sanctions;

9. Have written procedures describing all aspects of its certification program, maintain records of the current status of each individual's certification and the administration of its certification program;

10. Have procedures to ensure that certified individuals are provided due process with respect to the administration of its certification program, including the process of becoming certified and any sanctions imposed against certified individuals;

11. Have procedures for proctoring examinations, including qualifications for proctors. These procedures must ensure that the individuals proctoring each examination are not employed by the same company or corporation (or a wholly-owned subsidiary of such company or corporation) as any of the examinees;

12. Exchange information about certified individuals with the Department and other independent certifying organizations and/or the U.S. Nuclear Regulatory Commission and/or Agreement States and allow periodic review of its certification program and related records; and

13. Provide a description to the Department of its procedures for choosing examination sites and for providing an appropriate examination environment.

II. **Requirements for Certification Programs**.

All certification programs must:

1. Require applicants for certification to:

   A. Receive training in the topics set forth in RH-1804. or equivalent NRC and/or Agreement State Regulations; and

   B. Satisfactorily complete a written examination covering these topics.

2. Require applicants for certification to provide documentation that demonstrates that the applicant has:

   A. Received training in the topics set forth in RH-1804. or equivalent NRC and/or Agreement State regulations;

   B. Satisfactorily completed a minimum period of on-the-job training; and

   C. Received verification by an Agreement State or NRC licensee that the applicant has demonstrated the capability of independently working as a radiographer;

3. Include procedures to ensure that all examination questions are protected from disclosure;

4. Include procedures for denying an application, revoking, suspending, and reinstating a certificate;

5. Provide a certificate period of not less that three (3) years nor more than five (5) years;

6. Include procedures for renewing certifications and, if the procedures allow renewals without examination, require evidence of recent full-time employment and annual refresher training; and

7. Provide a timely response to inquiries, by telephone or letter, from members of the public, about an individual's certification status.

III. **Requirements for Written Examinations**.

All examinations must be:

1. Designed to test an individual's knowledge and understanding of the topics listed in RH-1804. or equivalent NRC and/or Agreement State regulations;

2. Written in a multiple-choice format; and

3. Have test items drawn from a question bank containing psychometrically valid questions based on the material in RH-1804.

PART J.
LICENSES AND RADIATION SAFETY REQUIREMENTS FOR WIRELINE SERVICE OPERATIONS AND SUBSURFACE TRACER STUDIES

RH-1900. **General Provisions**.

a. **Scope**.

The Regulations in this Part apply to all licensees who use sources of radiation for wireline service operations including mineral logging, radioactive markers or subsurface tracer studies.

b. **Purpose**.

The Regulations in this Part establish radiation safety requirements for persons utilizing sources of radiation for wireline service operations including mineral logging, radioactive markers and subsurface tracer studies. The requirements of this Part are in addition to and not in substitution for other applicable requirements of these Regulations.

c. **Definitions**.

Energy compensation source (ECS) - A small sealed source, with an activity not exceeding 100 microcuries (3.7 MBq), used within a logging tool, or other tool components, to provide a reference standard to maintain the tool's calibration when in use.

Field station - A facility where radioactive sources may be stored or used and from which equipment is dispatched to temporary job sites.

Fresh water aquifer - A geologic formation that is capable of yielding fresh water to a well or spring.

Injection tool - A device used for controlled subsurface injection of radioactive tracer material.

Irretrievable well logging source - Any sealed source containing radioactive material that is pulled off or not connected to the wireline that suspends the source in the well and for which all reasonable effort at recovery has been expended.

Logging assistant - Any individual who, under the personal supervision of a logging supervisor, handles sealed sources, tracers, or radiation producing machines that are not in logging tools or shipping containers or who performs surveys required by RH-1967.

Logging supervisor - Any individual who uses radioactive material or radiation producing machines, or provides personal supervision in the use of radioactive material or radiation producing machines at a temporary jobsite and who is responsible to the licensee for assuring compliance with the requirements of the Department's Regulations and the conditions of the license.

Logging tool - Any device used subsurface to perform well-logging.

Mineral logging - Any logging performed for the purpose of mineral exploration other than oil or gas.

Particle accelerator - Any machine capable of accelerating elections, protons, deuterons or other charged particles in a vacuum and of discharging the resultant particulate or other radiation into a medium at energies usually in excess of one (1) MeV.

Personal supervision - Guidance and instruction by the logging supervisor who is physically present at the job site and watching the performance of the operation in such proximity that contact can be maintained and immediate assistance given as required.

Radioactive marker - Radioactive material placed subsurface or on a structure intended for subsurface use for the purpose of depth determination or direction orientation.

Radioactive material - Byproduct, source or special nuclear material received, processed, used or transferred under a license issued by the Arkansas State Board of Health, Arkansas Department of Health under the regulations of this Part.

Sealed source - Any radioactive material that is encased in a capsule designed to prevent leakage or escape of the radioactive material.

Source holder - A housing or assembly into which a radioactive source is placed for the purpose of facilitating the handling and use of the source in well-logging operations.

RH-1900.c. (Cont'd)

Subsurface tracer study - the release of a substance tagged with radioactive material for the purpose of tracing the movement or position of the tagged substance in the well-bore or adjacent formation.

Surface casing for protecting fresh water aquifers - a pipe or tube used as a lining in a well to isolate fresh water aquifers from the well.

Temporary jobsite - A location to which radioactive materials have been dispatched to perform wireline service operations or subsurface tracer studies.

Tritium neutron generator target source - A tritium source used within a neutron generator tube to produce neutrons for use in well-logging applications.

Uranium sinker bar - A weight containing depleted uranium used to pull a logging tool toward the bottom of a well.

Well-bore - A drilled hole in which wireline service operations and subsurface tracer studies are performed.

Well-logging - the lowering and raising of measuring devices or tools which may contain sources of radiation into well-bores or cavities for the purpose of obtaining information about the well and/or adjacent formations.

Wireline - A cable containing one or more electrical conductors which is used to lower and raise logging tools in the well-bore.

Wireline service operation - Any evaluation or mechanical service which is performed in the well-bore using devices on a wireline.

RH-1901- RH-1910. Reserved.

RH-1911. **Application for a Specific License**.

A person, as defined in RH-1100., shall file an application for a specific license authorizing the use of radioactive material in well logging in accordance with RH-403. and RH-404.

RH-1912. Reserved.

RH-1913. **Specific Licenses for Well Logging**.

The Department will approve an application for a specific license for the use of radioactive material in well logging if the applicant meets the following requirements:

a. The application shall satisfy the general requirements specified in RH-404. of these Regulations, and any special requirements contained in this Part.

b. The applicant shall develop a program for training logging supervisors and logging assistants and submit to the Department a description of this program which specifies the:

1. Initial training;

2. On-the-job training;

3. Annual safety reviews provided by the licensee;

4. Means the applicant will use to demonstrate the logging supervisor's knowledge and understanding of and ability to comply with the Department's Regulations and licensing requirements and the applicant's operating and emergency procedures; and

5. Means the applicant will use to demonstrate the logging assistant's knowledge and understanding of and ability to comply with the applicant's operating and emergency procedures.

c. The applicant shall submit to the Department written operating and emergency procedures as described in RH-1963. or an outline or summary of the procedures that includes the important radiation safety aspects of the procedures.

d. The applicant shall establish and submit to the Department its program for annual inspections of the job performance of each logging supervisor to ensure that the Department's regulations, license requirements, and the applicant's operating and emergency procedures are followed. Inspection records must be retained for three (3) years after each annual internal inspection.

RH-1913. (Cont'd)

e. The applicant shall submit a description of its overall organizational structure as it applies to the radiation safety responsibilities in well logging, including specified delegations of authority and responsibility.

f. If an applicant wants to perform leak testing of sealed sources, the applicant shall identify the manufacturers and model numbers of the leak test kits to be used. If an applicant wants to analyze its own wipe samples, the applicant shall establish procedures to be followed and submit a description of these procedures to the Department. The description must include the:

1. Instruments to be used;

2. Methods of performing the analysis; and

3. Pertinent experience of the person who will analyze the wipe samples.

RH-1914. Reserved.

RH-1915. **Agreement with Well Owner or Operator**.

a. A licensee may perform well logging with a sealed source only after the licensee has a written agreement with the employing well owner or operator. This written agreement must identify who will meet the following requirements:

1 If a sealed source becomes lodged in the well, a reasonable effort will be made to recover it.

2. A person may not attempt to recover a sealed source in a manner which, in the licensee's opinion, could result in its rupture.

3. The radiation monitoring required in RH-1969.a. will be performed.

4. If the environment, any equipment, or personnel are contaminated with radioactive material, they must be decontaminated before release from the site or release for unrestricted use; and

5. If the sealed source is classified as irretrievable after reasonable efforts at recovery have been expended, the following requirements must be implemented within thirty (30) days:

   A. Each irretrievable well logging source must be immobilized and sealed in place with a cement plug;

   B. A means to prevent inadvertent intrusion on the source unless the source is not accessible to any subsequent drilling operations; and

   C. A permanent identification plaque, constructed of long-lasting material such as stainless steel, brass, bronze, or monel, must be mounted at the surface of the well, unless the mounting of the plaque is not practical. The size of the plaque must be at least seven (7) inches (17cm) square and 1/8-inch (3 mm) thick. The plaque[14/] must contain:

      i. The word "**CAUTION**";

      ii. The radiation symbol (the color requirement in RH-1303.a.1. need not be met);

      iii. The date the source was abandoned;

      iv. The name of the well owner or operator, as appropriate;

      v. The well name and well identification numbers(s) or other designation;

      vi. An identification of the sealed source(s) by radionuclide and quantity;

      vii. The depth of the source and depth to the top of the plug; and

      viii. An appropriate warning, such as "**DO NOT RE-ENTER THIS WELL**."[15/]

b. The licensee shall retain a copy of the written agreement for three (3) years after.

RH-1915. (Cont'd)

c. A licensee may apply, pursuant to RH-1991., for Department approval, on a case-by-case basis, of proposed procedures to abandon an irretrievable well logging source in a manner not otherwise authorized in RH-1915.a.5. of this section.

d. A written agreement between the licensee and the well owner or operator is not required if the licensee and the well owner or operator are part of the same corporate structure or otherwise similarly affiliated. However, the licensee shall still otherwise meet the requirements of RH-1915.a.1. through RH-1915.a.5.

RH-1916. Reserved.

RH-1917. **Request for Written Statements**.

Each license is issued with the condition that the licensee will, at any time before expiration of the license, upon the Department's request, submit written statements, signed under oath or affirmation, to enable the Department to determine whether or not the license should be modified, suspended, or revoked.

RH-1918.- RH-1930. Reserved.

RH-1931. **Labels, Security, and Transportation Precautions**.

a. **Labels**.

1. The licensee may not use a source, source holder, or logging tool that contains radioactive material unless the smallest component that is transported as a separate piece of equipment with the radioactive material inside bears a durable, legible, and clearly visible marking or label. The marking or label must contain the radiation symbol specified in RH-1303.a.1. and 2., without the conventional color requirements, and the wording

"**DANGER (or CAUTION) RADIOACTIVE MATERIAL**."

RH-1931.a. (Cont'd)

2. The licensee may not use a container to store radioactive material unless the container has a secure, visible label. The label must contain the radiation symbol specified in RH-1303.a. and the wording

"**CAUTION**,*
RADIOACTIVE MATERIAL,
NOTIFY CIVIL AUTHORITIES [or name of company] **IF FOUND**."

***or DANGER**

3. The licensee may not transport radioactive material unless the material is packaged, labeled, marked, and accompanied with appropriate shipping papers in accordance with Section 4 of these Regulations.

b. **Security precautions during storage and transportation**.

1. The licensee shall store each source containing radioactive material in a storage container or transportation package. The container or package must be locked and physically secured to prevent tampering or removal of radioactive material from storage by unauthorized personnel. The licensee shall store the radioactive material in a manner which will minimize the danger from explosion or fire.

2. The licensee shall lock and physically secure the transport package containing radioactive material in the transporting vehicle to prevent accidental loss, tampering, or unauthorized removal of the radioactive material from the vehicle.

RH-1932. Reserved.

RH-1933. **Radiation Detection Instruments**.

a. The licensee shall keep a calibrated and operable radiation survey instrument capable of detecting beta and gamma radiation at each field station and temporary jobsite to make the radiation surveys required by this Part and by other Parts of Section 3. To satisfy this requirement, the radiation survey instrument must be capable of measuring 0.1 mrem (0.001 mSv) per hour through at least 50 mrem (0.5 mSv) per hour.

RH-1933. (Cont'd)

b. The licensee shall have available additional calibrated and operable radiation detection instruments sensitive enough to detect the low radiation and contamination levels that could be encountered if a sealed source ruptured. The licensee may own the instruments or may have a procedure to obtain them quickly from a second party.

c. The licensee shall have each radiation survey instrument required under RH-1933.a.of this section calibrated:

1. At intervals not to exceed six (6) months and after instrument servicing;

2. For linear scale instruments, at two (2) points located approximately 1/3 and 2/3 of full-scale on each scale; for logarithmic scale instruments, at midrange of each decade, and at two (2) points of at least one decade; and for digital instruments, at appropriate points; and

3. So that an accuracy within plus or minus twenty percent (± 20%) of the calibration standard can be demonstrated on each scale.

d. The license shall retain calibration records for a period of three (3) years after the date of calibration for inspection by the Department.

RH-1934. Reserved.

RH-1935. **Leak Testing of Sealed Sources**.

a. **Testing and recordkeeping requirements**.

Each licensee who uses a sealed source shall have the source leak tested for leakage in accordance with RH-1212. and as prescribed in this section. The licensee shall keep a record of leak test results in units of microcuries and retain the record for inspection by the Department for three (3) years after the leak test is performed.

b. **Method of testing**.

The wipe of a sealed source must be performed using a leak test kit or method approved by the Department, the U.S. Nuclear Regulatory Commission, or an Agreement State. The wipe sample must be taken from the nearest accessible point to the sealed source where contamination might accumulate. The wipe sample must be analyzed for radioactive contamination. The analysis must be capable of detecting the presence of 0.005 microcuries (185 Bq) of radioactive material on the test sample and must be performed by a person approved by the Department, the U.S. Nuclear Regulatory Commission, or an Agreement State to perform the analysis.

c. **Test frequency**.

1. Each sealed source (except an energy compensation source (ECS)) must be tested at intervals not to exceed six (6) months. In the absence of a certificate from a transferor that a test has been made within the six (6) months before the transfer, the sealed source may not be used until tested.

2. Each ECS that is not exempt from testing in accordance with RH-1935.e. must be tested at intervals not to exceed three (3) years. In the absence of a certificate from a transferor that a test has been made within the three (3) years before the transfer, the ECS may not be used until tested.

d. **Removal of leaking source from service**.

1. If the test conducted pursuant to RH-1935.a. and RH-1935.b. reveals the presence of 0.005 microcuries (185 Bq) or more of removable radioactive material, the licensee shall remove the sealed source from service immediately and have it decontaminated, repaired, or disposed of by a Department, U.S. Nuclear Regulatory Commission, or an Agreement State licensee that is authorized to perform these functions. The licensee shall check the equipment associated with the leaking source for radioactive contamination and, if contaminated, have it decontaminated or disposed of by a Department, U.S. Nuclear Regulatory Commission, or an Agreement State licensee that is authorized to perform these functions.

RH-1935.d. (Cont'd)

2. The licensee shall submit a report to the Department within five (5) days of receiving the test results. The report must describe the equipment involved in the leak, the test results, any contamination which resulted from the leaking source, and the corrective actions taken up to the time the report is made.

e. **Exemptions from testing requirements**.

The following sealed sources are exempt from the periodic leak requirements set out in RH-1935.a. through RH-1935.d.:

1. Hydrogen-3 (tritium) sources;

2. Sources containing licensed material with a half-life of thirty (30) days or less;

3. Sealed sources containing licensed material in gaseous form;

4. Sources of beta- or gamma-emitting radioactive material with an activity of 100 microcuries (3.7 MBq) or less; and

5. Sources of alpha- or neutron-emitting radioactive material with an activity of ten (10) microcuries (0.37 MBq) or less.

RH-1936. Reserved.

RH-1937. **Physical Inventory**.

Each licensee shall conduct a quarterly physical inventory to account for all radioactive material received and possessed under the license. The licensee shall retain records of the inventory for three (3) years from the date of the inventory for inspection by the Department. The inventory must indicate the quantity and type of radioactive material, the location of the radioactive material, the date of the inventory, and the name of the individual conducting the inventory.

RH-1938. Reserved.

RH-1939. **Records of Material Use**.

a. Each licensee shall maintain records for each use of radioactive material showing:

1. The make, model number, and a serial number or a description of each sealed source used;

2. In the case of unsealed radioactive material used for subsurface tracer studies, the radionuclide and quantity of activity used in a particular well and the disposition of any unused tracer material;

3. The identity of the logging supervisor who is responsible for the licensed material and the identity of logging assistants present; and

4. The location and date of use of the radioactive material.

b. The licensee shall make the records required by RH-1939.a. of this section available for inspection by the Department. The licensee shall retain the records for three (3) years from the date of the recorded event.

RH-1940. Reserved.

RH-1941. **Design and Performance Criteria for Sealed Sources**.

a. A licensee may use a sealed source in well-logging applications if:

1. The sealed source is doubly encapsulated;

2. The sealed source licensed material whose chemical and physical forms are as insoluble and nondispersible as practical; and

3. Meets the requirements in RH-1941.b., c. or d.

b. For a sealed source manufactured on or before July 14, 1989, a licensee may use the sealed source, for use in well-logging applications if it meets the requirements of USASI N5.10-1968, "Classification of Sealed Radioactive Sources," or the requirements in RH-1941.c. or d.

c. For a sealed source manufactured after July 14, 1989, a licensee may use the sealed source, for use in well-logging applications if it meets the oil-well logging requirements of ANSI/HPS N43.6-1997, "Sealed Radioactive Sources-Classification."

RH-1941. (Cont'd)

d. For a sealed source manufactured after July 14, 1989, a licensee may use the sealed source, for use in well-logging applications, if:

1. The sealed source's prototype has been tested and found to maintain its integrity after each of the following tests:

A. **Temperature**.

The test source must be held at - 40º C for 20 minutes, 600º C for one (1) hour, and then be subject to a thermal shock test with a temperature drop from 600º C to 20º C within 15 seconds.

B. **Impact test**.

A 5 kg steel hammer, 2.5 cm in diameter, must be dropped from a height of one (1) meter onto the test source.

C. **Vibration test**.

The test source must be subject to a vibration from 25 Hz to 500 Hz at 5 gram amplitude for 30 minutes.

D. **Puncture test**.

A one (1) gram hammer and pin, 0.3 cm pin diameter, must be dropped from a height of one (1) meter onto the test source.

E. **Pressure test**.

The test source must be subject to an external pressure of 24,600 pounds per square inch absolute (1.695×10^7 pascals).

e. The requirements of RH-1941.a., b., c., and d. do not apply to sealed sources that contain radioactive material in gaseous form.

f. The requirements in RH-1941.a., b., c., and d. do not apply to energy compensation sources (ECS). ECSs must be registered with the U.S. Nuclear Regulatory Commission or with an Agreement State.

RH-1942. Reserved.

RH-1943. **Inspection, Maintenance, and Opening of a Source or Source Holder**.

a. Each licensee shall visually check source holders, logging tools, and source handling tools for defects before each use to ensure that the equipment is in good working condition and that required labeling is present. If defects are found, the equipment must be removed from service until repaired, and a record must be made listing: the date of the check, name of inspector, equipment involved, defects found, and repairs made. These records must be retained for three (3) years after the defect is found.

b. Each licensee shall have a program for semiannual visual inspection and routine maintenance of source holders, logging tools, injection tools, source handling tools, storage containers, transport containers, and uranium sinker bars to ensure that the required labeling is legible and that no physical damage is visible. If defects are found, the equipment must be removed from service until repaired, and a record must be made listing: date, equipment involved, inspection and maintenance operations performed, any defects found, and any actions taken to correct the defects. These records must be retained for three (3) years after the defect is found.

c. Removal of a sealed source from a source holder or logging tool, and maintenance on sealed sources or holders in which sealed sources are contained may not be performed by the licensee unless a written procedure developed pursuant to RH-1963. has been approved either by the Department, the U.S. Nuclear Regulatory Commission, or by an Agreement State pursuant to RH-1913.c.

d. If a sealed source is stuck in the source holder, the licensee may not perform any operation, such as drilling, cutting, or chiseling, on the source holder unless the licensee is specifically approved by the Department, the U.S. Nuclear Regulatory Commission, or by an Agreement State to perform this operation.

e. The opening, repair, or modification of any sealed source must be performed by persons specifically approved to do so by the Department, the U.S. Nuclear Regulatory Commission, or by an Agreement State.

RH-1944. Reserved.

RH-1945. **Subsurface Tracer Studies**.

a. The licensee shall require all personnel handling radioactive tracer material to use protective gloves and, if required by the license, other protective clothing and equipment. The licensee shall take precautions to avoid ingestion or inhalation of radioactive tracer material and to avoid contamination of field stations and temporary jobsites.

b. A licensee may not knowingly inject radioactive material into fresh water aquifers unless specifically authorized to do so by the Department.

RH-1946. **Particle Accelerators**.

No licensee shall permit above-ground testing of particle accelerators that results in the production of radiation, except in areas or facilities controlled or shielded so as to meet the requirements of RH-1200. and RH-1208. of these Regulations, as applicable.

RH-1947. **Radioactive Markers**.

The licensee may use radioactive markers in wells only if the individual markers contain quantities of radioactive material not exceeding the quantities specified in RH-901., Schedule B. The use of markers is subject to the requirements of RH-1937.

RH-1948. Reserved.

RH-1949. **Uranium Sinker Bars**.

The licensee may use a uranium sinker bar in well logging applications after July 14, 1988, only if it is legibly impressed with the words

"**CAUTION - RADIOACTIVE - DEPLETED URANIUM**"
and
"**NOTIFY CIVIL AUTHORITIES** [or name of company] **IF FOUND**."

RH-1950. Reserved.

RH-1951. **Use of a Sealed Source in a Well Without a Surface Casing**.

The licensee may use a sealed source in a well without a surface casing for protecting fresh water aquifers only if the licensee follows a procedure for reducing the probability of the source becoming lodged in the well. The procedure must be approved by the Department pursuant to RH-1913.

RH-1952. Reserved.

RH-1953. **Energy Compensation Source**.

The licensee may use an energy compensation source (ECS) which is contained within a logging tool, or other tool components, only if the ECS contains quantities of licensed material not exceeding 100 microcuries (3.7 MBq).

a. For well logging applications with a surface casing for protecting fresh water aquifers, use of the ECS is only subject to the requirements of RH-1935., RH-1937., and RH-1939.

b. For well logging applications without a surface casing for protecting fresh water aquifers, use of the ECS is only subject to the requirements of RH-1915., RH-1935., RH-1937., RH-1939., RH-1951., and RH-1977.

RH-1954. Reserved.

RH-1955. **Tritium Neutron Generator Target Source**.

a. Use of a tritium neutron generator target source, containing quantities not exceeding thirty (30) curies (1,110 MBq) and in a well with a surface casing to protect fresh water aquifers, is subject to the requirements of this part except for RH-1915., RH-1941., and RH-1977.

b. Use of a tritium neutron generator target source, containing quantities exceeding thirty (30) curies (1,110 MBq) or in a well without a surface casing to protect fresh water aquifers, is subject to the requirements of this Part except for RH-1941.

RH-1956- RH-1960. Reserved.

RH-1961. **Training**.

a. The licensee may not permit an individual to act as a logging supervisor until that person:

1. Has completed training in the subjects outlined in RH-1961.e. of this section;

2. Has received copies of, and instruction in:

A. The applicable Parts of Section 3 of these Regulations;

B. The license under which the logging supervisor will perform well logging; and

C. The licensee's operating and emergency procedures required by RH-1963.

3. Has completed on-the-job training and demonstrated competence in the use of radioactive materials, remote handling tools, and radiation survey instruments by a field evaluation; and

4. Has demonstrated understanding of the requirements in RH-1961.a.1. and RH-1961.a.2. by successfully completing a written test.

b. The licensee may not permit an individual to act as a logging assistant until that person:

1. Has received instruction in applicable Parts of Section 3 of these Regulations;

2. Has received copies of, and instruction in, the licensee's operating and emergency procedures required by RH-1963.;

3. Has demonstrated understanding of the material in RH-1961.b.1. and RH-1961.b.2. of this section by successfully completing a written or oral test; and

4. Has received instruction in the use of radioactive materials, remote handling tools, and radiation survey instruments, as appropriate for the logging assistant's intended job responsibilities.

c. The licensee shall provide safety reviews for logging supervisors and logging assistants at least once during each calendar year.

d. The licensee shall maintain a record on each logging supervisor's and logging assistant's training and annual safety review. The training records must include copies of written tests and dates of oral tests given after July 14, 1987. The training records must be retained until three (3) year following the termination of employment. Records of annual safety reviews must list the topics discussed and be retained for three (3) years.

e. The licensee shall include the following subjects in the training required in RH-1961.a.1. of this section.

1. Fundamentals of radiation safety, including:

A. Characteristics of radiation;

B. Units of radiation dose and quantity of radioactivity;

C. Hazards of exposure to radiation;

D. Levels of radiation from licensed material;

E. Methods of controlling radiation dose (time, distance, and shielding); and

F. Radiation safety practices, including prevention of contamination, and methods of decontamination.

2. Radiation detection instruments, including:

A. Use, operation, calibration, and limitations of radiation survey instruments;

B. Survey techniques; and

C. Use of personnel monitoring equipment.

3. Equipment to be used, including:

A. Operation of equipment, including source handling equipment and remote handling tools;

B. Storage, control, and disposal of radioactive material;

C. Maintenance of equipment.

RH-1961.e. (Cont'd)

4. The requirements of pertinent Department regulations; and

5. Case histories of accidents in well-logging.

RH-1962. Reserved.

RH-1963. **Operating and Emergency Procedures**.

Each licensee shall develop and follow written operating and emergency procedures that cover:

a. The handling and use of radioactive materials including the use of sealed sources in wells without surface casing for protecting fresh water aquifers, if appropriate;

b. The use of remote handling tools for handling sealed sources and radioactive tracer material except low-activity calibration sources;

c. Methods and occasions for conducting radiation surveys, including surveys for detecting contamination, as required by RH-1967.c. through RH-1967.e.;

d. Minimizing personnel exposure including exposures from inhalation and ingestion of radioactive tracer materials;

e. Methods and occasions for locking and securing stored radioactive materials;

f. Personnel monitoring and the use of personnel monitoring equipment;

g. Transportation of radioactive material to field stations or temporary jobsites, packaging of radioactive materials for transport in vehicles; placarding of vehicles when needed, and physically securing radioactive materials in transport vehicles during transportation to prevent accidental loss, tampering, or unauthorized removal;

h. Picking up, receiving, and opening packages containing radioactive materials, in accordance with RH-1307.;

i. For the use of tracers, decontamination of the environment, equipment, and personnel;

RH-1963. (Cont'd)

j. Maintenance of records generated by logging personnel at temporary jobsites;

k. The inspection and maintenance of sealed sources, source holders, logging tools, injection tools, source handling tools, storage containers, transport containers, and uranium sinker bars as required by RH-1943.;

l. Actions to be taken if a sealed source is lodged in a well;

m. Notifying proper persons in the event of an accident;

n. Actions to be taken if a sealed source is ruptured including actions to prevent the spread of contamination and minimize inhalation and ingestion of radioactive materials and actions to obtain suitable radiation survey instruments as required by RH-1933.b.; and

o. Identifying and reporting to the Department defects and noncompliance as required by RH-1935.d.2. and RH-1977.a., b., and d. of these regulations.

p. For particle accelerators, testing and use of the accelerator.

RH-1964. Reserved.

RH-1965. **Personnel Monitoring**.

a. The licensee may not permit an individual to act as a logging supervisor or logging assistant unless that persons wears, at all times during the handling of licensed radioactive materials, a personnel dosimeter that is processed and evaluated by an accredited National Voluntary Laboratory Accreditation Program (NVLAP) processor. Each personnel dosimeter must be assigned to and worn by only one (1) individual. Film badges must be replaced at least monthly and other personnel dosimeters replaced at least quarterly. After replacement, each personnel dosimeter must be promptly processed.

b. The licensee shall provide bioassay services to individuals using radioactive materials in subsurface tracer studies if required by the license.

c. The licensee shall retain records of personnel dosimeters and bioassay results for inspection until the Department authorizes disposition of the records.

RH-1966. Reserved.

RH-1967. **Radiation Surveys**.

a. The licensee shall make radiation surveys, including but not limited to the surveys required under RH-1967.b. through RH-1967.e. of this section, of each area where radioactive materials are used and stored.

b. Before transporting radioactive materials, the licensee shall make a radiation survey of the position occupied by each individual in the vehicle and of the exterior of each vehicle used to transport the radioactive materials.

c. If the sealed source assembly is removed from the logging tool before departure from the temporary jobsite, the licensee shall confirm that the logging tool is free of contamination by energizing the logging tool detector or by using a survey meter.

d. If the licensee has reason to believe that, as a result of any operation involving a sealed source, the encapsulation of the sealed source could be damaged by the operation, the licensee shall conduct a radiation survey, including a contamination survey, during and after the operation.

e. The licensee shall make a radiation survey at the temporary jobsite before and after each subsurface tracer study to confirm the absence of contamination, except those using hydrogen-3, carbon-14 and sulfur-35. These surveys shall include measurement of radiation levels before and after the operation.

f. The results of surveys required under RH-1967.a. through RH-1967.e. of this Section must be recorded and must include the date of the survey, the name of the individual making the survey, the identification of the survey, instrument used, and the location of the survey. The licensee shall retain records of surveys for inspection by the Department for three (3) years after they are made.

RH-1968. Reserved.

RH-1969. **Radioactive Contamination Control**.

a. If the licensee detects evidence that a sealed source has ruptured or radioactive materials have caused contamination, the licensee shall initiate immediately the emergency procedures required by RH-1963.

RH-1969. (Cont'd)

b. If contamination results from the use of radioactive material in well logging, the licensee shall decontaminate all work areas, equipment, and unrestricted areas.

c. During efforts to recover a sealed source lodged in the well, the licensee shall continuously monitor, with an appropriate radiation detection instrument or a logging tool with a radiation detector, the circulating fluids from the well, if any, to check for contamination resulting from damage to the sealed source.

RH-1970. Reserved.

RH-1971. **Security**.

a. A logging supervisor must be physically present at a temporary jobsite whenever radioactive materials are being handled or are not stored and locked in a vehicle or storage place. The logging supervisor may leave the jobsite in order to obtain assistance if a source becomes lodged in a well.

b. During well logging, except when radiation sources are below ground or in shipping or storage containers, the logging supervisor or other individual designated by the logging supervisor shall maintain direct surveillance of the operation to prevent unauthorized entry into a restricted area, as defined in RH-1100.

RH-1972. Reserved.

RH-1973. **Documents and Records Required at Field Stations**.

Each licensee shall maintain the following documents and records at the field station:

a. A copy of these Regulations;

b. The license authorizing the use of radioactive material;

c. Operating and emergency procedures required by RH-1963.;

RH-1973. (Cont'd)

d. The record of radiation survey instrument calibrations required by RH-1933.;

e. The record of leak test results required by RH-1935.;

f. Physical inventory records required by RH-1937.;

g. Utilization records required by RH-1939.;

h. Records of inspection and maintenance required by RH-1943.;

i. Training records required by RH-1961.d.; and

j. Survey records required by RH-1967.

RH-1974. Reserved.

RH-1975. **Documents and Records Required at Temporary Jobsites**.

Each licensee conducting operations at a temporary jobsite shall maintain the following documents and records at the temporary jobsite until the well-logging operation is completed:

a. Operating and emergency procedures required by RH-1963.;

b. Evidence of latest calibration of the radiation survey instruments in use at the site required by RH-1933.;

c. Latest survey records required by RH-1967.b., RH-1967.c., and RH-1967.e.

d. The shipping papers for the transportation of radioactive materials required by Section 4 of these Regulations;

e. When operating under reciprocity pursuant to Section 2, Part H of these Regulations, a copy of the U.S. Nuclear Regulatory Commission license or Agreement State license authorizing use of radioactive materials.

RH-1976. Reserved.

RH-1977. **Notification of Incidents and Lost Sources; Abandonment Procedures for Irretrievable Sources**.

a. The licensee shall immediately notify the Department by telephone and subsequently, within thirty (30) days, by confirmatory letter if the licensee knows or has reason to believe that a sealed source has been ruptured. The letter must designate the well or other location, describe the magnitude and extent of the escape of radioactive materials, assess the consequences of the rupture, and explain efforts planned or being taken to mitigate these consequences.

b. The licensee shall notify the Department of the theft or loss of radioactive materials, radiation overexposures, excessive levels and concentrations of radiation, and certain other accidents as required by RH-601., RH-1501., RH-1502., and RH-1504. of these Regulations..

c. If a sealed source becomes lodged in a well, and when it becomes apparent that efforts to recover the sealed source will not be successful, the licensee shall:

1. Notify the Department by telephone of the circumstances that resulted in the inability to retrieve the source and

A. Obtain the Department's approval to implement abandonment procedures; or

B. That the licensee implemented abandonment before receiving the Department's approval because the licensee believed there was an immediate threat to public health and safety; and

2. Advise the well owner or operator, as appropriate, of the abandonment procedures under RH-1915.a. or RH-1915.c.; and

3. Either ensure that abandonment procedures are implemented within thirty (30) days after the sealed source has been classified as irretrievable or request an extension of time if unable to complete the abandonment procedures.

RH-1977. (Cont'd)

d. The licensee shall, within thirty (30) days after a sealed source has been classified as irretrievable, make a report in writing to the Department. The licensee shall send a copy of the report to each appropriate State or Federal agency that issued permits or otherwise approved the drilling operation. The report shall contain the following information:

1. Date of occurrence;

2. A description of the irretrievable well-logging source involved including the radionuclide and its quantity, chemical, and physical form;

3. Surface location and identification of the well;

4. Results of effort to immobilize and seal the source in place;

5. A brief description of the attempted recovery effort;

6. Depth of the source;

7. Depth of the top of the cement plug;

8. Depth of the well;

9. The immediate threat to public health and safety justification for implementing abandonment if prior Department approval was not obtained in accordance with RH-1977.c.1.B.;

10. Any other information, such as a warning statement, contained on the permanent identification plaque; and

11. State and Federal agencies receiving a copy of this report.

RH-1978.- RH-1990. Reserved.

RH-1991. **Specific Exemptions**.

The Department may, upon application of any interested person or upon its own initiative, grant such exemptions from the requirements of the regulations in this Part as it determines are authorized by law and will not result in undue hazard to public health and safety or property, and are otherwise in the public interest.

RH-1992. **Subjects to be Included in Training Courses for Logging Supervisors**.

a. **Fundamentals of radiation safety**.

1. Characteristics of radiation.

2. Units of radiation dose (rem) and quantity of radioactivity (curie).

3. Significance of radiation dose.

A. Radiation protection standards.

B. Biological effects of radiation dose.

4. Levels of radiation from sources of radiation.

5. Methods of minimizing radiation dose.

A. Working time.

B. Working distances.

C. Shielding.

b. **Radiation detection instrumentation to be used**.

1. Use of radiation survey instruments.

A. Operation.

B. Calibration.

C. Limitations.

2. Survey techniques.

3. Use of personnel monitoring equipment.

c. **Equipment to be used**.

1. Handling equipment.

2. Sources of radiation.

3. Storage and control of equipment.

RH-1992.c. (Cont'd)

4. Operation and control of equipment.

d. The requirements of pertinent Federal and State regulations.

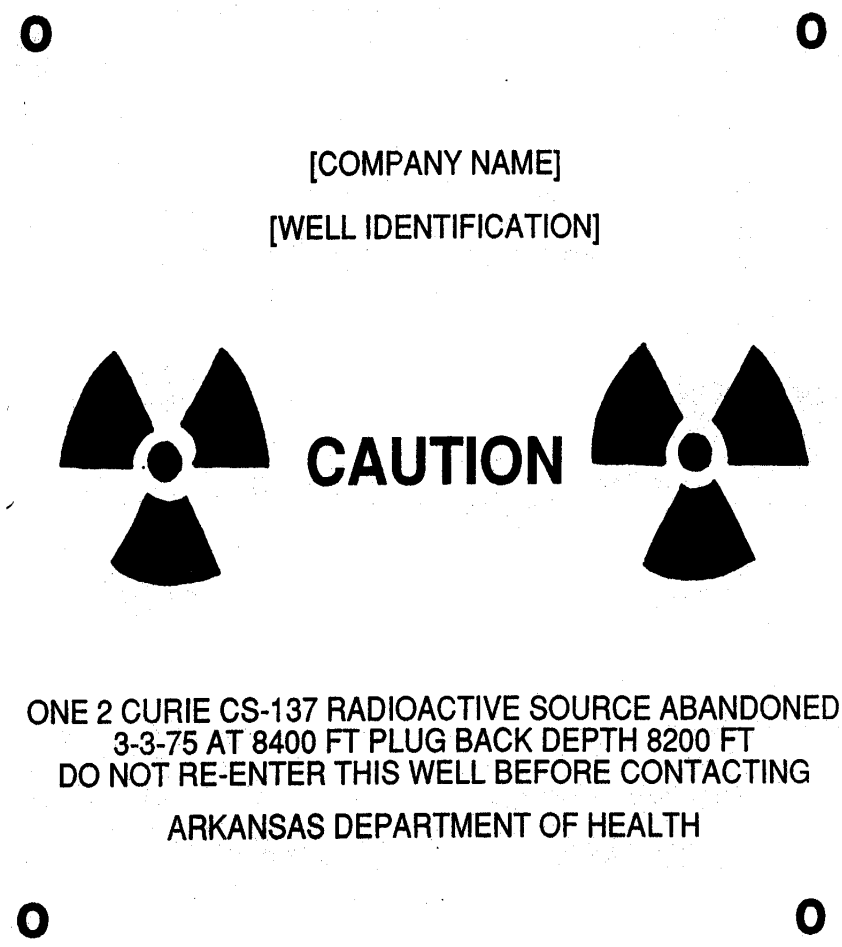
e. The licensee's written operating and emergency procedures.

f. The licensee's record keeping procedures.

RH-1993.- RH-1999. Reserved.

SCHEDULE C TO SECTION 3

EXAMPLE OF PLAQUE FOR IDENTIFYING WELLS CONTAINING SEALED SOURCES CONTAINING RADIOACTIVE MATERIAL ABANDONED DOWNHOLE



The size of the plaque should be convenient for use on active or inactive wells, e.g., a 7 inch square. Letter size of the word "CAUTION" should be approximately twice the letter size of the rest of the information, e.g., ½-inch and ¼-inch letter size, respectively.

PART K.
EXEMPTIONS AND ADDITIONAL REQUIREMENTS

RH-2000. **Specific Exemptions**.

The Department may, upon application of any interested person or upon its own initiative, grant such exemptions from the requirements of the regulations in this Section as it determines are authorized by law and will not result in undue hazard to public health and safety or property, and are otherwise in the public interest.

RH-2001. **Additional Requirements**.

The Department may, by rule, regulation, or order, impose upon any licensee such requirements in addition to those established in the regulations in this Section as it deems appropriate or necessary to minimize danger to public health and safety or property.

RH-2002.- RH-2109. Reserved.

PART L.
ENFORCEMENT

RH-2110. **Violations**.

a. An injunction or other court order may be obtained prohibiting any violation of any provision of the Act or any regulation or order issued thereunder. Any person who willfully violates any provision of the Act or any regulation or order issued thereunder may be guilty of a felony, misdemeanor, or crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law. Arkansas Code Annotated §20-21-204 describes criminal and civil penalties which may be assessed.

b. **Impounding**.

Sources of radiation shall be subject to impounding pursuant to Section 5 of these Regulations.

RH-2111.- RH-2199. Reserved.

PART M.
[RESERVED]

RH-2200.- RH-2799. Reserved.

PART N.
NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS; INSPECTIONS

RH-2800. Reserved.

RH-2801. **Purpose and Scope**.

This Part establishes requirements for notices, instructions, and reports by licensees or registrants to individuals engaged in work under a license or registration; and options available to such individuals in connection with Department inspection of licensees or registrants to ascertain compliance with the provisions of the Act and the regulations, orders, and licenses issued thereunder regarding radiological working conditions. The regulations in this Part apply to all persons who receive, possess, use, own, or transfer sources of radiation licensed by or registered with the Department pursuant to these Regulations in Sections 1 and 2, Part I of Section 3, Part J of Section 3, and Sections 6, 7, 8, and 9.

RH-2802. **Posting of Notices to Workers**.

a. Each licensee or registrant shall post current copies of the following documents:

1. A copy of these Regulations;

2. The license or certificate of registration, conditions or documents incorporated into the license by reference and amendments thereto;

3. The operating procedures applicable to work under the license or registration; and

4. Any notice of violation involving radiological working conditions or order issued pursuant to Section 5 and any response from the licensee or registrant.

b. If posting of a document specified in RH-2802.a.1., 2., or 3. is not practicable, the licensee or registrant may post a notice which describes the document and states where it may be examined.

c. Department Form X (Appendix I to Section 3), **"Notice to Employees**,**"** shall be posted by each licensee or registrant wherever individuals work in or frequent any portion of a restricted area.

RH-2802. (Cont'd)

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

e. Department documents posted pursuant to RH-2802.a.4. shall be posted within two (2) working days after receipt of the documents from the Department; the licensee's or registrant's response, if any, shall be posted within two (2) working days after dispatch from the licensee or registrant. Such documents shall remain posted for a minimum of five (5) working days or until action correcting the violation has been completed, whichever is later.

RH-2803. **Instructions to Workers**.

a. All individuals working in or frequenting any portion of a restricted area:

1. Shall be kept informed of the storage, transfer or use of radioactive materials or of radiation in such portions of the restricted area;

2. Shall be instructed in the health protection problems associated with exposure to radiation and/or radioactive material, in precautions or procedures to minimize exposure, and the purposes and functions of protective devices employed;

3. Shall be instructed in, and required to observe, to the extent within the worker's control, the applicable provisions of Department regulations and licenses or registration for the protection of personnel from exposures to radiation or radioactive material;

4. Shall be instructed of their responsibility to report promptly to the licensee or registrant any condition which may lead to or cause a violation of Department regulations and licenses or unnecessary exposure to radiation and/or radioactive material;

5. Shall be instructed in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation and/or radioactive material; and

6. Shall be advised as to the radiation exposure reports which workers may request pursuant to RH-2804.

RH-2803. (Cont'd)

b. In determining those individuals subject to the requirements of RH-2803.a., licensees and registrants must take into consideration assigned activities during normal and abnormal situations involving exposure to radiation and/or radioactive material which can reasonably be expected to occur during the life of a licensed or registered facility. The extent of these instructions shall be commensurate with potential radiological health protection problems present in the work place.

RH-2804. **Notifications and Reports to Individuals**.

a. Radiation exposure data for an individual and the results of any measurements, analyses and calculations of radioactive material deposited or retained in the body of an individual shall be reported to the individual as specified in this section. The information reported shall include data and results obtained pursuant to Department Regulations, orders or license conditions, as shown in records maintained by the licensee or registrant pursuant to Department Regulations. Each notification and report shall:

1. Be in writing;

2. Include appropriate identifying data such as the name of the licensee or registrant, the name of the individual, the individual's date of birth and the individual's social security number or other unique identifier;

3. Include the individual's exposure information; and

4. Contain the following statement:

"This report is furnished to you under the provisions of Arkansas Department of Health Regulations entitled 'Standards for Protection Against Radiation.' You should preserve this report for further reference."

b. Each licensee or registrant shall make dose information available to workers as shown in records maintained by the licensee or registrant under the provisions of RH-1500.f. The licensee or registrant shall provide an annual report to each individual monitored under RH-1302. of the dose received in that monitoring year if:

1. The individual's occupational dose exceeds 100 mrem (1 mSv) TEDE or 100 mrem (1 mSv) to any individual organ or tissue; or

2. The individual requests his or her annual dose report.

c. At the request of a worker formerly engaged in work controlled by the licensee or the registrant, each licensee or registrant shall furnish to the worker a report of the worker's exposure to radiation or radioactive material. Such report shall:

1. Be furnished within thirty (30) days from the time the request is made or within thirty (30) days after the exposure of the individual has been determined by the licensee or registrant, whichever is later;

2. Cover, within the period of time specified in the request, each calendar year in which the worker's activities involved exposure to radiation from radioactive material licensed by, or radiation machines registered with, the Department; and

3. Include the dates and locations of work under the license or registration in which the worker participated during this period.

d. Each licensee or registrant shall furnish to each worker a report of the worker's exposure to radiation or radioactive material upon termination of employment. Such report shall be furnished within thirty (30) days from the time of termination of employment or within thirty (30) days after the exposure of the individual has been determined by the licensee or registrant, whichever is later. The report shall cover each calendar year in which the worker's activities involved exposure to sources of radiation and shall include the dates and locations of work under the license or registration in which the worker participated.

e. At the request of a worker who is terminating employment with the licensee or registrant in work involving radiation dose, or of a worker who, while employed by another person, is terminating assignment to work involving radiation dose in the licensee's or registrant's facility, to each such worker, or to the worker's designee, at termination, a written report regarding the radiation dose received by that worker from operations of the licensee or registrant during that specifically identified calendar year or fraction thereof shall be provided, or a written estimate of that dose must be provided if the finally determined personnel monitoring results are not available at that time. Estimated doses shall be clearly indicated as such.

RH-2804. (Cont'd)

f. When a licensee or registrant is required pursuant to RH-1502., RH-1503., or RH-1504. to report to the Department any exposure of an individual to radiation or radioactive material, the licensee or the registrant shall also provide the individual a report on his or her exposure data included in the report to the Department. The report must be transmitted no later than the transmittal to the Department.

RH-2805. **Presence of Representatives of Licensees or Registrants and Workers During Inspections**.

a. Each licensee or registrant shall afford to the Department at all reasonable times opportunity to inspect materials, machines, activities, facilities, premises, and records pursuant to these Regulations.

b. During an inspection, Department inspectors may consult privately with workers as specified in RH-2806. The licensee or registrant may accompany Department inspectors during other phases of an inspection.

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

d. Each workers' representative shall be routinely engaged in work under control of the licensee or registrant and shall have received instructions as specified in RH-2803.

e. Different representatives of licensees or registrants and workers may accompany the inspectors during different phases of an inspection if there is no resulting interference with the conduct of the inspections; however, only one workers' representative at a time may accompany the inspectors.

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

RH-2805. (Cont'd)

g. Notwithstanding the other provisions of this section, Department inspectors are authorized to refuse to permit accompaniment by any individual who deliberately interferes with a fair and orderly inspection. With regard to any area containing proprietary information, the workers' representative for that area shall be an individual previously authorized by the licensee or registrant to enter that area.

RH-2806. **Consultation With Workers During Inspections**.

a. Department inspectors may consult privately with workers concerning matters of occupational radiation protection and other matters related to applicable provisions of Department regulations and licenses to the extent the inspectors deem necessary for the conduct of an effective and thorough inspection.

b. During the course of an inspection, any worker may bring privately to the attention of the inspectors, either orally or in writing, any past or present condition which he/she has reason to believe may have contributed to or caused any violation of the Act, these Regulations, or license condition, or any unnecessary exposure of an individual to radiation from licensed radioactive material or a registered radiation machine under the licensee's or registrant's control. Any such notice in writing shall comply with the requirements of RH-2807.a.

RH-2807. **Requests by Workers for Inspections**.

a. Any worker or representative of workers who believes that a violation of the Act, these Regulations or license conditions exists or has occurred in work under a license or registration with regard to radiological working conditions in which the worker is engaged, may request an inspection by giving notice of the alleged violation to the Department. Any such notice shall be in writing, shall set forth the specific grounds for the notice and shall be signed by the worker or representative of the workers. A copy shall be provided to the licensee or registrant by the Department no later than at the time of the inspection except that, upon the request of the worker giving such notice, his/her name and the name of individuals referred to therein shall not appear in such copy or on any record published, released or made available by the Department, except for good cause shown.

RH-2807. (Cont'd)

b. If, upon receipt of such notice, the Department determines that the complaint meets the requirements set forth in RH-2807.a., and that there are reasonable grounds to believe that the alleged violation exists or has occurred, an inspection shall be made as soon as practicable, to determine if such alleged violation exists or has occurred. Inspections pursuant to this section need not be limited to matters referred to in the complaint.

c. No licensee or registrant shall discharge or in any manner discriminate against any worker because such worker has filed any complaint or instituted or caused to be instituted any proceeding under these Regulations or has testified or is about to testify in any such proceeding or because of the exercise by such worker on behalf of himself/herself or others of any option afforded by this Part.

RH-2808. **Inspections Not Warranted; Informal Review**.

a. If the Department determines, with respect to a complaint under RH-2807., that an inspection is not warranted because there are no reasonable grounds to believe that a violation exists or has occurred, the Department shall notify the complainant in writing of such determination.

1. The complainant may obtain review of such determination by submitting a written statement of position to the Director who will provide the licensee or registrant with a copy of such statement by certified mail, excluding, at the request of the complainant, the name of the complainant.

2. The licensee or registrant may submit an opposing written statement of position to the Director who will provide the complainant with a copy of such statement by certified mail.

3. Upon the request of the complainant, the Director may hold an informal conference in which the complainant and the licensee or registrant may orally present their views. An informal conference may also be held at the request of the licensee or registrant, but disclosure of the identity of the complainant will be made only following receipt of written authorization from the complainant.

4. After considering all written or oral views presented, the Director shall affirm, modify, or reverse the determination of the Department and furnish the complainant and the licensee or registrant a written notification of his/her decision and the reason therefore.

RH-2808. (Cont'd)

b. If the Director determines that an inspection is not warranted because the requirements of RH-2807.a. have not been met, he/she shall notify the complainant in writing of such determination. Such determination shall be without prejudice to the filing of a new complaint meeting the requirements of RH-2807.a.

RH-2809.- RH-2899. Reserved.

PART O.
RADIATION SAFETY REQUIREMENTS FOR ANALYTICAL X-RAY EQUIPMENT

RH-2900. **Scope and Purpose**.

This Part provides special requirements for analytical x-ray equipment. The requirements of this Part are in addition to, and not in substitution for, applicable requirements in other parts of these Regulations.

RH-2901. **Definitions**.

Analytical x-ray equipment - X-Ray equipment used for x-ray diffraction fluorescence analysis or spectroscopy.

Analytical x-ray system - A group of local and remote components utilizing x-rays to determine the elemental composition or to examine the microstructure of materials. Local components include those that are struck by x-rays such as radiation source housings, port and shutter assemblies, collimators, sample holders, cameras, goniometers, detectors and shielding. Remote components include power supplies, transformers, amplifiers, readout devices, and control panels.

Fail-safe characteristics - A design feature which causes beam port shutters to close or otherwise prevents emergence of the primary beam, upon the failure of a safety or warning device.

Local components - Part of an analytical x-ray system and include areas exposed to x-rays, such as radiation source housings, port and shutter assemblies, collimators, sample holders, cameras, goniometers, detectors and shielding, but does not include power supplies, transformers, amplifiers, readout devices and control panels.

Normal operating procedures - Operating procedures for conditions suitable for analytical purposes with shielding and barriers in place. These do not include maintenance but do include routine alignment procedures. Routine and emergency radiation safety considerations are part of these procedures.

Open-beam configuration - An analytical x-ray system in which an individual could accidentally place some part of his/her body in the primary beam path during normal operation.

RH-2901. (Cont'd)

Primary beam - Ionizing radiation which passes through an aperture of the source housing by a direct path from the x-ray tube located in the radiation source housing.

RH-2902. **Equipment Requirements**.

a. **Safety device**.

A device which prevents the entry of any portion of an individual's body into the primary x-ray beam path or which causes the beam to be shut off upon entry into its path shall be provided on all open-beam configurations. A registrant may apply to the Department for an exemption from the requirement of a safety device. Such application shall include:

1. A description of the various safety devices that have been evaluated;

2. The reason each of these devices cannot be used; and

3. A description of the alternative methods that will be employed to minimize the possibility of an accidental exposure, including procedures to assure that operators and others in the area will be informed of the absence of safety devices.

b. **Warning devices**.

1. Open-beam configurations shall be provided with a readily discernible indication of:

A. X-ray tube status **(ON-OFF)** located near the radiation source housing, if the primary beam is controlled in this manner; and/or

B. Shutter status **(OPEN-CLOSED)** located near each port on the radiation source housings, if the primary beam is controlled in this manner.

2. Warning devices shall be labeled so that their purpose is easily identified. On equipment installed after January 1, 1979, warning devices shall have fail-safe characteristics.

c. **Ports**.

Unused ports on radiation machine source housings shall be secured in the closed position in a manner which will prevent casual opening.

d. **Labeling**.

All analytical x-ray equipment shall be labeled with a readily discernible sign or signs bearing the radiation symbol and the words:

1. "**CAUTION - HIGH INTENSITY X-RAY BEAM**," or words having a similar intent, on the x-ray source housing; and

2. "**CAUTION RADIATION - THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED**," or words having a similar intent, near any switch that energizes an x-ray tube.

e. **Shutters**.

On open-beam configurations installed after January 1, 1979, each port on the radiation source housing shall be equipped with a shutter that cannot be opened unless a collimator or a coupling has been connected to the port.

f. **Warning lights**.

1. An easily visible warning light labeled with the words "**X-RAY ON**" or words having a similar intent, shall be located near any switch that energizes an x-ray tube and shall be illuminated only when the tube is energized.

2. On equipment installed after January 1, 1979, warning lights shall have fail-safe characteristics.

g. **Radiation source housing**.

Each radiation source housing shall be subject to the following requirements:

1. Each x-ray tube housing shall be equipped with an interlock that shuts off the tube if it is removed from the radiation source housing or if the housing is disassembled.

RH-2902. (Cont'd)

h. **Generator cabinet**.

Each x-ray generator shall be supplied with a protective cabinet which limits leakage radiation measured at a distance of 5 centimeters from its surface such that it is not capable of producing a dose in excess of 0.25 millirem in one hour.

RH-2903. **Area Requirements**.

a. **Radiation levels**.

The local components of an analytical x-ray system shall be located and arranged and shall include sufficient shielding or access control such that no radiation levels exist in any area surrounding the local component group which could result in a dose to an individual present therein in excess of the dose limits given in RH-1208. These levels shall be met at any specified tube rating.

b. **Surveys**.

1. Radiation surveys, as required by RH-1300., of all analytical x-ray systems sufficient to show compliance with RH-2903.a. shall be performed:

A. Upon installation of the equipment;

B. Following any change in the initial arrangement, number or type of local components in the system;

C. Following any maintenance requiring the disassembly or removal of a local component in the system;

D. During the performance of maintenance and alignment procedures, if the procedures require the presence of a primary x-ray beam when any local component in the system is disassembled or removed;

E. Any time a visual inspection of the local components in the system reveals an abnormal condition; and

F. Whenever personnel monitoring devices show a significant increase over the previous monitoring period or the readings are approaching the limits specified in RH-1200.

RH-2903.b. (Cont'd)

2. Radiation survey measurements shall not be required if a registrant can demonstrate compliance to the satisfaction of the Department with RH-2903.a. in some other manner.

c. **Posting**.

Each area or room containing analytical x-ray equipment shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words "**CAUTION - X-RAY EQUIPMENT**" or words having a similar intent.

RH-2904. **Operating Requirements**.

a. **Procedures**.

Normal operating procedures shall be written and available to all analytical x-ray equipment workers. No person shall be permitted to operate analytical x-ray equipment in any manner other than that specified in the procedures unless such person has obtained written approval of the Radiation Safety Officer.

b. **Bypassing**.

No person shall bypass a safety device unless such person has obtained the approval of the Radiation Safety Officer. When a safety device has been bypassed, a readily discernible sign bearing the words "**SAFETY DEVICE NOT WORKING**," or words having a similar intent, shall be placed on the radiation source housing.

c. **Repair or modification of x-ray tube systems**.

Except as specified in RH-2904.b., no operation involving removal of covers, shielding materials or tube housings or modifications to shutters, collimators or beam stops shall be performed without ascertaining that the tube is off and will remain off until safe conditions have been restored. The main switch, rather than interlocks, shall be used for routine shutdown in preparation for repairs.

RH-2905. **Personnel Requirements**.

a. **Instruction**.

1. No person shall be permitted to operate or maintain analytical x-ray equipment unless such person has received instruction in and demonstrated competence as to:

A. Identification of radiation hazards associated with the use of the equipment;

B. Significance of the various radiation warning and safety devices incorporated into the equipment or the reasons they have not been installed on certain pieces of equipment and the extra precautions required in such cases;

C. Proper operating procedures for the equipment;

D. Symptoms of an acute localized exposure; and

E. Proper procedures for reporting an actual or suspected exposure.

b. **Personnel monitoring**.

1. Finger or wrist dosimetric devices shall be provided to and shall be used by:

A. Analytical x-ray equipment workers using systems having an open-beam configuration and not equipped with a safety device; and

B. Personnel maintaining analytical x-ray equipment if the maintenance procedures require the presence of a primary x-ray beam when any local component in the analytical x-ray system is disassembled or removed.

2. Reported dose values shall not be used for the purpose of determining compliance with RH-1200. and RH-1208. unless evaluated by a qualified expert.

RH-2906.- RH-2999. Reserved.

APPENDIX A TO SECTION 3

Deleted. (See Appendix G to Section 3.)

APPENDIX B TO SECTION 3

Deleted. (For RH-409.h. purposes, see Appendix E to Section 2. For RH-1303.b.5. purposes, see Appendix H to Section 3.)

APPENDIX C TO SECTION 3

Deleted. (For "Determination of A_1 and A_2 Quantities," see Appendix A to Section 4.)

APPENDIX D TO SECTION 3

NATIONALLY TRACKED SOURCE THRESHOLDS

(for use with RH-1513.)

The Terabecquerel (TBq) values are the regulatory standard. The curie (Ci) values specified are obtained by converting from the TBq value. The curie values are provided for practical usefulness only and are rounded after conversion.

Radioactive material	Category 1 (TBq)	Category 1 (Ci)	Category 2 (TBq)	Category 2 (Ci)
Actinium-227	20	540	0.2	5.4
Americium-241	60	1,600	0.6	16
Americium-241/Be	60	1,600	0.6	16
Californium-252	20	540	0.2	5.4
Cobalt-60	30	810	0.3	8.1
Curium-244	50	1,400	0.5	14
Cesium-137	100	2,700	1	27
Gadolinium-153	1,000	27,000	10	270
Iridium-192	80	2,200	0.8	22
Plutonium-238	60	1,600	0.6	16
Plutonium-239/Be	60	1,600	0.6	16
Polonium-210	60	1,600	0.6	16
Promethium-147	40,000	1,100,000	400	11,000
Radium-226	40	1,100	0.4	11
Selenium-75	200	5,400	2	54
Strontium-90	1,000	27,000	10	270
Thorium-228	20	540	0.2	5.4
Thorium-229	20	540	0.2	5.4
Thulium-170	20,000	540,000	200	5,400
Ytterbium-169	300	8,100	3	81

APPENDIX E TO SECTION 3

ASSIGNED PROTECTION FACTORS FOR RESPIRATORS [a/]

RESPIRATOR TYPE	OPERATING MODE	ASSIGNED PROTECTION FACTOR
I. Air Purifying Respirators [Particulate [b/] only][c/]		
Filtering facepiece disposable [d/]	Negative Pressure	([d/])
Facepiece, half [e/]	Negative Pressure	10
Facepiece, full	Negative Pressure	100
Facepiece, half	Powered air-purifying respirators	50
Facepiece, full	Powered air-purifying respirator	1000
Helmet/hood	Powered air-purifying respirator	1000
Facepiece, loose-fitting	Powered air-purifying respirator	25
II. Atmosphere supplying respirators [particulate, gases and vapors [f/]]		
1. Air-line respirators		
Facepiece, half	Demand	10
Facepiece, half	Continuous flow	50
Facepiece, half	Pressure demand	50
Facepiece, full	Demand	100
Facepiece, full	Continuous flow	1000
Facepiece, full	Pressure demand	1000
Helmet/hood	Continuous flow	1000
Facepiece, loose-fitting	Continuous flow	25
Suit	Continuous flow	([g/])
2. Self-contained breathing apparatus (SCBA)		
Facepiece, full	Demand	100 [h/]
Facepiece, full	Pressure demand	10,000 [i/]
Facepiece, full	Demand, re-circulating	100 [h/]
Facepiece, full	Positive pressure re-circulating	10,000 [i/]
III. Combination Respirators		
Any combination of air-purifying and atmosphere-supplying respirators	Assigned protection factor for type and mode of operation as listed above	

Footnotes for Appendix E to Section 3:

a/ These assigned protection factors apply only in a respiratory protection program that meets the requirements of this Section. They are applicable only to airborne radiological hazards and may not be appropriate to circumstances when chemical or other respiratory hazards exist instead of, or in addition to, radioactive hazards. Selection and use of respirators for such circumstances must also comply with Department of Labor regulations. Radioactive contaminants for which the concentration values in Table I, Column 3 of Appendix G to Section 3 are based on internal dose due to inhalation may, in addition, present external exposure hazards at higher concentrations. Under these circumstances, limitation 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 ninety-five percent (95%) efficient. Air purifying respirators with APF = 100 must be equipped with particulate filters that are at least ninety-nine percent (99%) efficient. Air purifying respirators with APFs > 100 must be equipped with particulate filters that are at least 99.97 percent (99.97%) efficient.

c/ The licensee may apply to the Department for the use of an APF greater than one (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 seal check on this type of device. All other respiratory protection program requirements listed in RH-1303.f. apply. An assigned protection factor has not been assigned for these devices. However, an APF equal to ten (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 ninety-five percent (95%) efficient and all other requirement 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 three (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 atmosphere supplying suits. This equipment may be used in an acceptable respiratory protection program as long as all the other minimum program requirements, with the exception of fit testing, are met (i.e., RH-1303.f.).

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

Footnotes for Appendix E to Section 3 (Cont'd):

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 limitation 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 F TO SECTION 3

LIST OF ELEMENTS FOR USE WITH APPENDIX G TO SECTION 3

Name	Symbol	Atomic number	Name	Symbol	Atomic number
Actinium	Ac	89	Iodine	I	53
Aluminum	Al	13	Iridium	Ir	77
Americium	Am	95	Iron	Fe	26
Antimony	Sb	51	Krypton	Kr	36
Argon	Ar	18	Lanthanum	La	57
Arsenic	As	33	Lead	Pb	82
Astatine	At	85	Lutetium	Lu	71
Barium	Ba	56	Magnesium	Mg	12
Berkelium	Bk	97	Manganese	Mn	25
Beryllium	Be	4	Mendelevium	Md	101
Bismuth	Bi	83	Mercury	Hg	80
Bromine	Br	35	Molybdenum	Mo	42
Cadmium	Cd	48	Neodymium	Nd	60
Calcium	Ca	20	Neptunium	Np	93
Californium	Cf	98	Nickel	Ni	28
Carbon	C	6	Niobium	Nb	41
Cerium	Ce	58	Nitrogen	N	7
Cesium	Cs	55	Osmium	Os	76
Chlorine	Cl	17	Oxygen	O	8
Chromium	Cr	24	Palladium	Pd	46
Cobalt	Co	27	Phosphorus	P	15
Copper	Cu	29	Platinum	Pt	78
Curium	Cm	96	Plutonium	Pu	94
Dysprosium	Dy	66	Polonium	Po	84
Einsteinium	Es	99	Potassium	K	19
Erbium	Er	68	Praseodymium	Pr	59
Europium	Eu	63	Promethium	Pm	61
Fermium	Fm	100	Protactinium	Pa	91
Fluorine	F	9	Radium	Ra	88
Francium	Fr	87	Radon	Rn	86
Gadolinium	Gd	64	Rhenium	Re	75
Gallium	Ga	31	Rhodium	Rh	45
Germanium	Ge	32	Rubidium	Rb	37
Gold	Au	79	Ruthenium	Ru	44
Hafnium	Hf	72	Samarium	Sm	62
Holmium	Ho	67	Scandium	Sc	21
Hydrogen	H	1	Selenium	Se	34
Indium	In	49	Silicon	Si	14

Appendix F to Section 3 (Cont'd)

Name	Symbol	Atomic number
Silver	Ag	47
Sodium	Na	11
Strontium	Sr	38
Sulfur	S	16
Tantalum	Ta	73
Technetium	Tc	43
Tellurium	Te	52
Terbium	Tb	65
Thallium	Tl	81
Thorium	Th	90
Thulium	Tm	69
Tin	Sn	50
Titanium	Ti	22
Tungsten	W	74
Uranium	U	92
Vanadium	V	23
Xenon	Xe	54
Ytterbium	Yb	70
Yttrium	Y	39
Zinc	Zn	30
Zirconium	Zr	40

APPENDIX G TO SECTION 3

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

Introduction

For each radionuclide, Table I indicates the chemical form which is to be used for selecting the appropriate ALI or DAC value. The ALIs and DACs for inhalation are given for an aerosol with an activity median aerodynamic diameter (AMAD) of 1 μm (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. The class (D, W, or Y) given in the column headed "Class" applies only to the inhalation ALIs and DACs given in Table I, column 2 and 3. 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 6×10^{-2} or 0.06, 6E+2 represents 6×10^{2} or 600, and 6E+0 represents 6×10^{0} or 6.

Table I: Occupational Values

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

The ALIs in this appendix are the annual intakes of given radionuclide by "Reference man" which would result in either (1) a committed effective dose equivalent of 0.05 sievert (5 rem), stochastic ALI, or (2) a committed dose equivalent of 0.5 sievert (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 sievert (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 RH-1100. 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 5 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 4 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 sievert (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, $\sum$ (intake (in μCi) of each radionuclide/ALI_{ns}) <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 < 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:

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

where 2 x 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 1 of 2 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 RH-1201. When an individual is exposed to radioactive materials which fall under several of the translocation classifications of the same radionuclide, such as Class D, Class W, or Class Y, the exposure may be evaluated as if it were a mixture of different radionuclides.

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

Table II : Effluent Concentrations

The columns in Table II of this appendix captioned "Effluents," "Air" and "Water" are applicable to the assessment and control of dose to the public, particularly in the implementation of the provisions of RH-1209. 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 millisievert (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 as was the case in Appendix B to 10 CFR Part 20.1-20.601.

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 2.4×10^9 (ml), relating the inhalation ALI to the DAC, as explained above, and then divided by a factor of 300. The factor of 300 includes the following components: a factor of 50 to relate the 0.05 sievert (5 rem) annual occupational dose limit to the 1 millisievert (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 7.3×10^7. The factor of 7.3×10^7 (ml) includes the following components: the factors of 50 and 2 described above and a factor of 7.3×10^5 (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.

Table III: Releases to Sewers

The monthly average concentrations for release to sanitary sewers are applicable to the provisions in RH-1402. The concentration values were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3×10^6 (ml). The factor of 7.3×10^6 (ml) is composed of a factor of 7.3×10^5 (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.

Appendix G to Section 3 (Cont'd)

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
1	Hydrogen-3	Water, DAC includes skin absorption	8E+4	8E+4	2E-5	1E-7	1E-3	1E-2
		Gas (HT or T_2) Submersion[a/]: Use above values as HT and T_2 oxidize in air and in the body to HTO.						
4	Beryllium-7	W, all compounds except those given for Y	4E+4	2E+4	9E-6	3E-8	6E-4	6E-3
		Y, oxides, halides, and nitrates	–	2E+4	8E-6	3E-8	–	–
4	Beryllium-10	W, see ^{7}Be	1E+3	2E+2	6E-8	2E-10	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{7}Be	–	1E+1	6E-9	2E-11	–	–
6	Carbon-11[b/]	Monoxide	–	1E+6	5E-4	2E-6	–	–
		Dioxide	–	6E+5	3E-4	9E-7	–	–
		Compounds	4E+5	4E+5	2E-4	6E-7	6E-3	6E-2
6	Carbon-14	Monoxide	–	2E+6	7E-4	2E-6	–	–
		Dioxide	–	2E+5	9E-5	3E-7	–	–
		Compounds	2E+3	2E+3	1E-6	3E-9	3E-5	3E-4
7	Nitrogen-13[b/]	Submersion[a/]	–	–	4E-6	2E-8	–	–
8	Oxygen-15[b/]	Submersion[a/]	–	–	4E-6	2E-8	–	–
9	Fluorine-18[b/]	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	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

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

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
17	Chlorine-38[b/]	D, see ^{36}Cl	2E+4	4E+4	2E-5	6E-8	–	–
			St wall (3E+4)	–	–	–	3E-4	3E-3
		W, see ^{36}Cl	–	5E+4	2E-5	6E-8	–	–
17	Chlorine-39[b/]	D, see ^{36}Cl	2E+4	5E+4	2E-5	7E-8	–	–
			St wall (4E+4)	–	–	–	5E-4	5E-3
		W, see ^{36}Cl	–	6E+4	2E-5	8E-8	–	–
18	Argon-37	Submersion[a/]	–	–	1E+0	6E-3	–	–
18	Argon-39	Submersion[a/]	–	–	2E-4	8E-7	–	–
18	Argon-41	Submersion[a/]	–	–	3E-6	1E-8	–	–
19	Potassium-40	D, all compounds	3E+2	4E+2	2E-7	6E-10	4E-6	4E-5
19	Potassium-42	D, all compounds	5E+3	5E+3	2E-6	7E-9	6E-5	6E-4
19	Potassium-43	D, all compounds	6E+3	9E+3	4E-6	1E-8	9E-5	9E-4
19	Potassium-44[b/]	D, all compounds	2E+4	7E+4	3E-5	9E-8	–	–
			St wall (4E+4)	–	–	–	5E-4	5E-3
19	Potassium-45[b/]	D, all compounds	3E+4	1E+5	5E-5	2E-7	–	–
			St wall (5E+4)	–	–	–	7E-4	7E-3
20	Calcium-41	W, all compounds	3E+3	4E+3	2E-6	–	–	–
			Bone surf (4E+3)	Bone surf (4E+3)	–	5E-9	6E-5	6E-4
20	Calcium-45	W, all compounds	2E+3	8E+2	4E-7	1E-9	2E-5	2E-4
20	Calcium-47	W, all compounds	8E+2	9E+2	4E-7	1E-9	1E-5	1E-4
21	Scandium-43	Y, all compounds	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
21	Scandium-44m	Y, all compounds	5E+2	7E+2	3E-7	1E-9	7E-6	7E-5
21	Scandium-44	Y, all compounds	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
21	Scandium-46	Y, all compounds	9E+2	2E+2	1E-7	3E-10	1E-5	1E-4
21	Scandium-47	Y, all compounds	2E+3	3E+3	1E-6	4E-9	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
21	Scandium-48	Y, all compounds	8E+2	1E+3	6E-7	2E-9	1E-5	1E-4

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
21	Scandium-49[b/]	Y, all compounds	2E+4	5E+4	2E-5	8E-8	3E-4	3E-3
22	Titanium-44	D, all compounds except those given for W and Y	3E+2	1E+1	5E-9	2E-11	4E-6	4E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	–	3E+1	1E-8	4E-11	–	–
		Y, SrTi0	–	6E+0	2E-9	8E-12	–	–
22	Titanium-45	D, see ^{44}Ti	9E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{44}Ti	–	4E+4	1E-5	5E-8	–	–
		Y, see ^{44}Ti	–	3E+4	1E-5	4E-8	–	–
23	Vanadium-47[b/]	D, all compounds except those given for W	3E+4	8E+4	3E-5	1E-7	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
		W, oxides, hydroxides, carbides, and halides	–	1E+5	4E-5	1E-7	–	–
23	Vanadium-48	D, see ^{47}V	6E+2	1E+3	5E-7	2E-9	9E-6	9E-5
		W, see ^{47}V	–	6E+2	3E-7	9E-10	–	–
23	Vanadium-49	D, see ^{47}V	7E+4	3E+4	1E-5	–	–	–
			LLI wall (9E+4)	Bone surf (3E+4)	–	5E-8	1E-3	1E-2
		W, see ^{47}V	–	2E+4	8E-6	2E-8	–	–
24	Chromium-48	D, all compounds except those given for W and Y	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, halides and nitrates	–	7E+3	3E-6	1E-8	–	–
		Y, oxides and hydroxides	–	7E+3	3E-6	1E-8	–	–
24	Chromium-49[b/]	D, see ^{48}Cr	3E+4	8E+4	4E-5	1E-7	4E-4	4E-3
		W, see ^{48}Cr	–	1E+5	4E-5	1E-7	–	–
		Y, see ^{48}Cr	–	9E+4	4E-5	1E-7	–	–
24	Chromium-51	D, see ^{48}Cr	4E+4	5E+4	2E-5	6E-8	5E-4	5E-3
		W, see ^{48}Cr	–	2E+4	1E-5	3E-8	–	–
		Y, see ^{48}Cr	–	2E+4	8E-6	3E-8	–	–
25	Manganese-51[b/]	D, all compounds except those given for W	2E+4	5E+4	2E-5	7E-8	3E-4	3E-3
		W, oxides, hydroxides, halides, and nitrates	–	6E+4	3E-5	8E-8	–	–
25	Manganese-52m[b/]	D, see ^{51}Mn	3E+4	9E+4	4E-5	1E-7	–	–
			St wall (4E+4)	–	–	–	5E-4	5E-3
		W, see ^{51}Mn	–	1E+5	4E-5	1E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

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

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values: Col. 1 Oral Ingestion ALI (µCi)	Table I Occupational Values: Inhalation Col. 2 ALI (µCi)	Table I Occupational Values: Inhalation Col. 3 DAC (µCi/ml)	Table II Effluent Concentrations: Col. 1 Air (µCi/ml)	Table II Effluent Concentrations: Col. 2 Water (µCi/ml)	Table III Releases to Sewers: Monthly Average Concentration (µCi/ml)
27	Cobalt-60	W, see ^{55}Co	5E+2	2E+2	7E-8	2E-10	3E-6	3E-5
		Y, see ^{55}Co	2E+2	3E+1	1E-8	5E-11	–	–
27	Cobalt-61[b/]	W, see ^{55}Co	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		Y, see ^{55}Co	2E+4	6E+4	2E-5	8E-8	–	–
27	Cobalt-62m[b/]	W, see ^{55}Co	4E+4	2E+5	7E-5	2E-7	–	–
			St wall (5E+4)	–	–	–	7E-4	7E-3
		Y, see ^{55}Co	–	2E+5	6E-5	2E-7	–	–
28	Nickel-56	D, all compounds except those given for W	1E+3	2E+3	8E-7	3E-9	2E-5	2E-4
		W, oxides, hydroxides, and carbides	–	1E+3	5E-7	2E-9	–	–
		Vapor	–	1E+3	5E-7	2E-9	–	–
28	Nickel-57	D, see ^{56}Ni	2E+3	5E+3	2E-6	7E-9	2E-5	2E-4
		W, see ^{56}Ni	–	3E+3	1E-6	4E-9	–	–
		Vapor	–	6E+3	3E-6	9E-9	–	–
28	Nickel-59	D, see ^{56}Ni	2E+4	4E+3	2E-6	5E-9	3E-4	3E-3
		W, see ^{56}Ni	–	7E+3	3E-6	1E-8	–	–
		Vapor	–	2E+3	8E-7	3E-9	–	–
28	Nickel-63	D, see ^{56}Ni	9E+3	2E+3	7E-7	2E-9	1E-4	1E-3
		W, see ^{56}Ni	–	3E+3	1E-6	4E-9	–	–
		Vapor	–	8E+2	3E-7	1E-9	–	–
28	Nickel-65	D, see ^{56}Ni	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{56}Ni	–	3E+4	1E-5	4E-8	–	–
		Vapor	–	2E+4	7E-6	2E-8	–	–
28	Nickel-66	D, see ^{56}Ni	4E+2	2E+3	7E-7	2E-9	–	–
			LLI wall (5E+2)	–	–	–	6E-6	6E-5
		W, see ^{56}Ni	–	6E+2	3E-7	9E-10	–	–
		Vapor	–	3E+3	1E-6	4E-9	–	–
29	Copper-60[b/]	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 ^{60}Cu	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{60}Cu	–	4E+4	2E-5	6E-8	–	–
		Y, see ^{60}Cu	–	4E+4	1E-5	5E-8	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (µCi)	Table I Occupational Values Col. 2 Inhalation ALI (µCi)	Table I Occupational Values Col. 3 Inhalation DAC (µCi/ml)	Table II Effluent Concentrations Col. 1 Air (µCi/ml)	Table II Effluent Concentrations Col. 2 Water (µCi/ml)	Table III Releases to Sewers Monthly Average Concentration (µCi/ml)
29	Copper-64	D, see ^{60}Cu	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{60}Cu	–	2E+4	1E-5	3E-8	–	–
		Y, see ^{60}Cu	–	2E+4	9E-6	3E-8	–	–
29	Copper-67	D, see ^{60}Cu	5E+3	8E+3	3E-6	1E-8	6E-5	6E-4
		W, see ^{60}Cu	–	5E+3	2E-6	7E-9	–	–
		Y, see ^{60}Cu	–	5E+3	2E-6	6E-9	–	–
30	Zinc-62	Y, all compounds	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
30	Zinc-63[b/]	Y, all compounds	2E+4	7E+4	3E-5	9E-8	–	–
			St wall (3E+4)	–	–	–	3E-4	3E-3
30	Zinc-65	Y, all compounds	4E+2	3E+2	1E-7	4E-10	5E-6	5E-5
30	Zinc-69m	Y, all compounds	4E+3	7E+3	3E-6	1E-8	6E-5	6E-4
30	Zinc-69[b/]	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[b/]	D, all compounds except those given for W	5E+4	2E+5	7E-5	2E-7	–	–
			St wall (6E+4)	–	–	–	9E-4	9E-3
		W, oxides, hydroxides, carbides, halides, and nitrates	–	2E+5	8E-5	3E-7	–	–
31	Gallium-66	D, see ^{65}Ga	1E+3	4E+3	1E-6	5E-9	1E-5	1E-4
		W, see ^{65}Ga	–	3E+3	1E-6	4E-9	–	–
31	Gallium-67	D, see ^{65}Ga	7E+3	1E+4	6E-6	2E-8	1E-4	1E-3
		W, see ^{65}Ga	–	1E+4	4E-6	1E-8	–	–
31	Gallium-68[b/]	D, see ^{65}Ga	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{65}Ga	–	5E+4	2E-5	7E-8	–	–
31	Gallium-70[b/]	D, see ^{65}Ga	5E+4	2E+5	7E-5	2E-7	–	–
			St wall (7E+4)	–	–	–	1E-3	1E-2
		W, see ^{65}Ga	–	2E+5	8E-5	3E-7	–	–
31	Gallium-72	D, see ^{65}Ga	1E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see ^{65}Ga	–	3E+3	1E-6	4E-9	–	–
31	Gallium-73	D, see ^{65}Ga	5E+3	2E+4	6E-6	2E-8	7E-5	7E-4
		W, see ^{65}Ga	–	2E+4	6E-6	2E-8	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
32	Germanium-66	D, all compounds except those given for W	2E+4	3E+4	1E-5	4E-8	3E-4	3E-3
		W, oxides, sulfides, and halides	–	2E+4	8E-6	3E-8	–	–
32	Germanium-67[b/]	D, see ^{66}Ge	3E+4	9E+4	4E-5	1E-7	–	–
			St wall (4E+4)	–	–	–	6E-4	6E-3
		W, see ^{66}Ge	–	1E+5	4E-5	1E-7	–	–
32	Germanium-68	D, see ^{66}Ge	5E+3	4E+3	2E-6	5E-9	6E-5	6E-4
		W, see ^{66}Ge	–	1E+2	4E-8	1E-10	–	–
32	Germanium-69	D, see ^{66}Ge	1E+4	2E+4	6E-6	2E-8	2E-4	2E-3
		W, see ^{66}Ge	–	8E+3	3E-6	1E-8	–	–
32	Germanium-71	D, see ^{66}Ge	5E+5	4E+5	2E-4	6E-7	7E-3	7E-2
		W, see ^{66}Ge	–	4E+4	2E-5	6E-8	–	–
32	Germanium-75[b/]	D, see ^{66}Ge	4E+4	8E+4	3E-5	1E-7	–	–
			St wall (7E+4)	–	–	–	9E-4	9E-3
		W, see ^{66}Ge	–	8E+4	4E-5	1E-7	–	–
32	Germanium-77	D, see ^{66}Ge	9E+3	1E+4	4E-6	1E-8	1E-4	1E-3
		W, see ^{66}Ge	–	6E+3	2E-6	8E-9	–	–
32	Germanium-78[b/]	D, see ^{66}Ge	2E+4	2E+4	9E-6	3E-8	–	–
			St wall (2E+4)	–	–	–	3E-4	3E-3
		W, see ^{66}Ge	–	2E+4	9E-6	3E-8	–	–
33	Arsenic-69[b/]	W, all compounds	3E+4	1E+5	5E-5	2E-7	–	–
			St wall (4E+4)	–	–	–	6E-4	6E-3
33	Arsenic-70[b/]	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

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
33	Arsenic-77	W, all compounds	4E+3	5E+3	2E-6	7E-9	–	–
			LLI wall (5E+3)	–	–	–	6E-5	6E-4
33	Arsenic-78[b/]	W, all compounds	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
34	Selenium-70[b/]	D, all compounds except those given for W	2E+4	4E+4	2E-5	5E-8	1E-4	1E-3
		W, oxides, hydroxides, carbides, and elemental Se	1E+4	4E+4	2E-5	6E-8	–	–
34	Selenium-73m[b/]	D, see ^{70}Se	6E+4	2E+5	6E-5	2E-7	4E-4	4E-3
		W, see ^{70}Se	3E+4	1E+5	6E-5	2E-7	–	–
34	Selenium-73	D, see ^{70}Se	3E+3	1E+4	5E-6	2E-8	4E-5	4E-4
		W, see ^{70}Se	–	2E+4	7E-6	2E-8	–	–
34	Selenium-75	D, see ^{70}Se	5E+2	7E+2	3E-7	1E-9	7E-6	7E-5
		W, see ^{70}Se	–	6E+2	3E-7	8E-10	–	–
34	Selenium-79	D, see ^{70}Se	6E+2	8E+2	3E-7	1E-9	8E-6	8E-5
		W, see ^{70}Se	–	6E+2	2E-7	8E-10	–	–
34	Selenium-81m[b/]	D, see ^{70}Se	4E+4	7E+4	3E-5	9E-8	3E-4	3E-3
		W, see ^{70}Se	2E+4	7E+4	3E-5	1E-7	–	–
34	Selenium-81[b/]	D, see ^{70}Se	6E+4	2E+5	9E-5	3E-7	–	–
			St wall (8E+4)	–	–	–	1E-3	1E-2
		W, see ^{70}Se	–	2E+5	1E-4	3E-7	-	-
34	Selenium-83[b/]	D, see ^{70}Se	4E+4	1E+5	5E-5	2E-7	4E-4	4E-3
		W, see ^{70}Se	3E+4	1E+5	5E-5	2E-7	–	–
35	Bromine-74m[b/]	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	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
35	Bromine-74[b/]	D, see ^{74m}Br	2E+4	7E+4	3E-5	1E-7	–	–
			St wall (4E+4)	–	–	–	5E-4	5E-3
		W, see ^{74m}Br	–	8E+4	4E-5	1E-7	–	–
35	Bromine-75[b/]	D, see ^{74m}Br	3E+4	5E+4	2E-5	7E-8	–	–
			St wall (4E+4)	–	–	–	5E-4	5E-3
		W, see ^{74m}Br	–	5E+4	2E-5	7E-8	–	–
35	Bromine-76	D, see ^{74m}Br	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
		W, see ^{74m}Br	–	4E+3	2E-6	6E-9	–	–
35	Bromine-77	D, see ^{74m}Br	2E+4	2E+4	1E-5	3E-8	2E-4	2E-3
		W, see ^{74m}Br	–	2E+4	8E-6	3E-8	–	–
35	Bromine-80m	D, see ^{74m}Br	2E+4	2E+4	7E-6	2E-8	3E-4	3E-3
		W, see ^{74m}Br	–	1E+4	6E-6	2E-8	–	–
35	Bromine-80[b/]	D, see ^{74m}Br	5E+4	2E+5	8E-5	3E-7	–	–
			St wall (9E+4)	–	–	–	1E-3	1E-2
		W, see ^{74m}Br	–	2E+5	9E-5	3E-7	–	–
35	Bromine-82	D, see ^{74m}Br	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
		W, see ^{74m}Br	–	4E+3	2E-6	5E-9	–	–
35	Bromine-83	D, see ^{74m}Br	5E+4	6E+4	3E-5	9E-8	–	–
			St wall (7E+4)	–	–	–	9E-4	9E-3
		W, see ^{74m}Br	–	6E+4	3E-5	9E-8	–	–
35	Bromine-84[b/]	D, see ^{74m}Br	2E+4	6E+4	2E-5	8E-8	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
		W, see ^{74m}Br	–	6E+4	3E-5	9E-8	–	–
36	Krypton-74[b/]	Submersion[a/]	–	–	3E-6	1E-8	–	–
36	Krypton-76	Submersion[a/]	–	–	9E-6	4E-8	–	–
36	Krypton-77[b/]	Submersion[a/]	–	–	4E-6	2E-8	–	–
36	Krypton-79	Submersion[a/]	–	–	2E-5	7E-8	–	–
36	Krypton-81	Submersion[a/]	–	–	7E-4	3E-6	–	–
36	Krypton-83m[b/]	Submersion[a/]	–	–	1E-2	5E-5	–	–
36	Krypton-85m	Submersion[a/]	–	–	2E-5	1E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
36	Krypton-85	Submersion[a/]	–	–	1E-4	7E-7	–	–
36	Krypton-87[b/]	Submersion[a/]	–	–	5E-6	2E-8	–	–
36	Krypton-88	Submersion[a/]	–	–	2E-6	9E-9	–	–
37	Rubidium-79[b/]	D, all compounds	4E+4	1E+5	5E-5	2E-7	–	–
			St wall (6E+4)	–	–	–	8E-4	8E-3
37	Rubidium-81m[b/]	D, all compounds	2E+5	3E+5	1E-4	5E-7	–	–
			St wall (3E+5)	–	–	–	4E-3	4E-2
37	Rubidium-81	D, all compounds	4E+4	5E+4	2E-5	7E-8	5E-4	5E-3
37	Rubidium-82m	D, all compounds	1E+4	2E+4	7E-6	2E-8	2E-4	2E-3
37	Rubidium-83	D, all compounds	6E+2	1E+3	4E-7	1E-9	9E-6	9E-5
37	Rubidium-84	D, all compounds	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
37	Rubidium-86	D, all compounds	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
37	Rubidium-87	D, all compounds	1E+3	2E+3	6E-7	2E-9	1E-5	1E-4
37	Rubidium-88[b/]	D, all compounds	2E+4	6E+4	3E-5	9E-8	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
37	Rubidium-89[b/]	D, all compounds	4E+4	1E+5	6E-5	2E-7	–	–
			St wall (6E+4)	–	–	–	9E-4	9E-3
38	Strontium-80[b/]	D, all soluble compounds except $SrTiO_3$	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		Y, all insoluble compounds and $SrTi0_3$	–	1E+4	5E-6	2E-8	–	–
38	Strontium-81[b/]	D, see ^{80}Sr	3E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		Y, see ^{80}Sr	2E+4	8E+4	3E-5	1E-7	–	–
38	Strontium-82	D, see ^{80}Sr	3E+2	4E+2	2E-7	6E-10	–	–
			LLI wall (2E+2)	–	–	–	3E-6	3E-5
		Y, see ^{80}Sr	2E+2	9E+1	4E-8	1E-10	–	–
38	Strontium-83	D, see ^{80}Sr	3E+3	7E+3	3E-6	1E-8	3E-5	3E-4
		Y, see ^{80}Sr	2E+3	4E+3	1E-6	5E-9	–	–
38	Strontium-85m[b/]	D, see ^{80}Sr	2E+5	6E+5	3E-4	9E-7	3E-3	3E-2
		Y, see ^{80}Sr	–	8E+5	4E-4	1E-6	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
38	Strontium-85	D, see ^{80}Sr	3E+3	3E+3	1E-6	4E-9	4E-5	4E-4
		Y, see ^{80}Sr	–	2E+3	6E-7	2E-9	–	–
38	Strontium-87m	D, see ^{80}Sr	5E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		Y, see ^{80}Sr	4E+4	2E+5	6E-5	2E-7	–	–
38	Strontium-89	D, see ^{80}Sr	6E+2	8E+2	4E-7	1E-9	–	–
			LLI wall (6E+2)	–	–	–	8E-6	8E-5
		Y, see ^{80}Sr	5E+2	1E+2	6E-8	2E-10	–	–
38	Strontium-90	D, see ^{80}Sr	3E+1	2E+1	8E-9	–	–	–
			Bone surf (4E+1)	Bone surf (2E+1)	–	3E-11	5E-7	5E-6
		Y, see ^{80}Sr	–	4E+0	2E-9	6E-12	–	–
38	Strontium-91	D, see ^{80}Sr	2E+3	6E+3	2E-6	8E-9	2E-5	2E-4
		Y, see ^{80}Sr	–	4E+3	1E-6	5E-9	–	–
38	Strontium-92	D, see ^{80}Sr	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{80}Sr	–	7E+3	3E-6	9E-9	–	–
39	Yttrium-86m[b/]	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 ^{86m}Y	1E+3	3E+3	1E-6	5E-9	2E-5	2E-4
		Y, see ^{86m}Y	–	3E+3	1E-6	5E-9	–	–
39	Yttrium-87	W, see ^{86m}Y	2E+3	3E+3	1E-6	5E-9	3E-5	3E-4
		Y, see ^{86m}Y	–	3E+3	1E-6	5E-9	–	–
39	Yttrium-88	W, see ^{86m}Y	1E+3	3E+2	1E-7	3E-10	1E-5	1E-4
		Y, see ^{86m}Y	–	2E+2	1E-7	3E-10	–	–
39	Yttrium-90m	W, see ^{86m}Y	8E+3	1E+4	5E-6	2E-8	1E-4	1E-3
		Y, see ^{86m}Y	–	1E+4	5E-6	2E-8	–	–
39	Yttrium-90	W, see ^{86m}Y	4E+2	7E+2	3E-7	9E-10	–	–
			LLI wall (5E+2)	–	–	–	7E-6	7E-5
		Y, see ^{86m}Y	–	6E+2	3E-7	9E-10	–	–
39	Yttrium-91m[b/]	W, see ^{86m}Y	1E+5	2E+5	1E-4	3E-7	2E-3	2E-2
		Y, see ^{86m}Y	–	2E+5	7E-5	2E-7	–	–
39	Yttrium-91	W, see ^{86m}Y	5E+2	2E+2	7E-8	2E-10	–	–
			LLI wall (6E+2)	–	–	–	8E-6	8E-5
		Y, see ^{86m}Y	–	1E+2	5E-8	2E-10	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
39	Yttrium-92	W, see ^{86m}Y	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{86m}Y	–	8E+3	3E-6	1E-8	–	–
39	Yttrium-93	W, see ^{86m}Y	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, see ^{86m}Y	–	2E+3	1E-6	3E-9	–	–
39	Yttrium-94[b/]	W, see ^{86m}Y	2E+4	8E+4	3E-5	1E-7	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
		Y, see ^{86m}Y	–	8E+4	3E-5	1E-7	–	–
39	Yttrium-95[b/]	W, see ^{86m}Y	4E+4	2E+5	6E-5	2E-7	–	–
			St wall (5E+4)	–	–	–	7E-4	7E-3
		Y, see ^{86m}Y	–	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 ^{86}Zr	4E+3	2E+2	9E-8	3E-10	5E-5	5E-4
		W, see ^{86}Zr	–	5E+2	2E-7	7E-10	–	–
		Y, see ^{86}Zr	–	3E+2	1E-7	4E-10	–	–
40	Zirconium-89	D, see ^{86}Zr	2E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see ^{86}Zr	–	2E+3	1E-6	3E-9	–	–
		Y, see ^{86}Zr	–	2E+3	1E-6	3E-9	–	–
40	Zirconium-93	D, see ^{86}Zr	1E+3	6E+0	3E-9	–	–	–
			Bone surf (3E+3)	Bone surf (2E+1)	–	2E-11	4E-5	4E-4
		W, see ^{86}Zr	–	2E+1	1E-8	–	–	–
			–	Bone surf (6E+1)	–	9E-11	–	–
		Y, see ^{86}Zr	–	6E+1	2E-8	–	–	–
			–	Bone surf (7E+1)	–	9E-11	–	–
40	Zirconium-95	D, see ^{86}Zr	1E+3	1E+2	5E-8	–	2E-5	2E-4
			–	Bone surf (3E+2)	–	4E-10	–	–
		W, see ^{86}Zr	–	4E+2	2E-7	5E-10	–	–
		Y, see ^{86}Zr	–	3E+2	1E-7	4E-10	–	–
40	Zirconium-97	D, see ^{86}Zr	6E+2	2E+3	8E-7	3E-9	9E-6	9E-5
		W, see ^{86}Zr	–	1E+3	6E-7	2E-9	–	–
		Y, see ^{86}Zr	–	1E+3	5E-7	2E-9	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values: Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values: Inhalation Col. 2 ALI (μCi)	Table I Occupational Values: Inhalation Col. 3 DAC (μCi/ml)	Table II Effluent Concentrations: Col. 1 Air (μCi/ml)	Table II Effluent Concentrations: Col. 2 Water (μCi/ml)	Table III Releases to Sewers: Monthly Average Concentration (μCi/ml)
41	Niobium-88[b/]	W, all compounds except those given for Y	5E+4	2E+5	9E-5	3E-7	–	–
			St wall (7E+4)	–	–	–	1E-3	1E-2
		Y, oxides and hydroxides	–	2E+5	9E-5	3E-7	–	–
41	Niobium-89[b/] (66 min)	W, see ^{88}Nb	1E+4	4E+4	2E-5	6E-8	1E-4	1E-3
		Y, see ^{88}Nb	–	4E+4	2E-5	5E-8	–	–
41	Niobium-89 (122 min)	W, see ^{88}Nb	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		Y, see ^{88}Nb	–	2E+4	6E-6	2E-8	–	–
41	Niobium-90	W, see ^{88}Nb	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
		Y, see ^{88}Nb	–	2E+3	1E-6	3E-9	–	–
41	Niobium-93m	W, see ^{88}Nb	9E+3	2E+3	8E-7	3E-9	–	–
			LLI wall (1E+4)	–	–	–	2E-4	2E-3
		Y, see ^{88}Nb	–	2E+2	7E-8	2E-10	–	–
41	Niobium-94	W, see ^{88}Nb	9E+2	2E+2	8E-8	3E-10	1E-5	1E-4
		Y, see ^{88}Nb	–	2E+1	6E-9	2E-11	–	–
41	Niobium-95m	W, see ^{88}Nb	2E+3	3E+3	1E-6	4E-9	–	–
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
		Y, see ^{88}Nb	–	2E+3	9E-7	3E-9	–	–
41	Niobium-95	W, see ^{88}Nb	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
		Y, see ^{88}Nb	–	1E+3	5E-7	2E-9	–	–
41	Niobium-96	W, see ^{88}Nb	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, see ^{88}Nb	–	2E+3	1E-6	3E-9	–	–
41	Niobium-97[b/]	W, see ^{88}Nb	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		Y, see ^{88}Nb	–	7E+4	3E-5	1E-7	–	–
41	Niobium-98[b/]	W, see ^{88}Nb	1E+4	5E+4	2E-5	8E-8	2E-4	2E-3
		Y, see ^{88}Nb	–	5E+4	2E-5	7E-8	–	–
42	Molybdenum-90	D, all compounds except those given for Y	4E+3	7E+3	3E-6	1E-8	3E-5	3E-4
		Y, oxides, hydroxides, and MoS_2	2E+3	5E+3	2E-6	6E-9	–	–
42	Molybdenum-93m	D, see ^{90}Mo	9E+3	2E+4	7E-6	2E-8	6E-5	6E-4
		Y, see ^{90}Mo	4E+3	1E+4	6E-6	2E-8	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
42	Molybdenum-93	D, see ^{90}Mo	4E+3	5E+3	2E-6	8E-9	5E-5	5E-4
		Y, see ^{90}Mo	2E+4	2E+2	8E-8	2E-10	–	–
42	Molybdenum-99	D, see ^{90}Mo	2E+3	3E+3	1E-6	4E-9	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{90}Mo	1E+3	1E+3	6E-7	2E-9	–	–
42	Molybdenum-101[b]	D, see ^{90}Mo	4E+4	1E+5	6E-5	2E-7	–	–
			St wall (5E+4)	–	–	–	7E-4	7E-3
		Y, see ^{90}Mo	–	1E+5	6E-5	2E-7	–	–
43	Technetium-93m[b]	D, all compounds except those given for W	7E+4	2E+5	6E-5	2E-7	1E-3	1E-2
		W, oxides, hydroxides, halides, and nitrates	–	3E+5	1E-4	4E-7	–	–
43	Technetium-93	D, see ^{93m}Tc	3E+4	7E+4	3E-5	1E-7	4E-4	4E-3
		W, see ^{93m}Tc	–	1E+5	4E-5	1E-7	–	–
43	Technetium-94m[b]	D, see ^{93m}Tc	2E+4	4E+4	2E-5	6E-8	3E-4	3E-3
		W, see ^{93m}Tc	–	6E+4	2E-5	8E-8	–	–
43	Technetium-94	D, see ^{93m}Tc	9E+3	2E+4	8E-6	3E-8	1E-4	1E-3
		W, see ^{93m}Tc	–	2E+4	1E-5	3E-8	–	–
43	Technetium-95m	D, see ^{93m}Tc	4E+3	5E+3	2E-6	8E-9	5E-5	5E-4
		W, see ^{93m}Tc	–	2E+3	8E-7	3E-9	–	–
43	Technetium-95	D, see ^{93m}Tc	1E+4	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{93m}Tc	–	2E+4	8E-6	3E-8	–	–
43	Technetium-96m[b]	D, see ^{93m}Tc	2E+5	3E+5	1E-4	4E-7	2E-3	2E-2
		W, see ^{93m}Tc	–	2E+5	1E-4	3E-7	–	–
43	Technetium-96	D, see ^{93m}Tc	2E+3	3E+3	1E-6	5E-9	3E-5	3E-4
		W, see ^{93m}Tc	–	2E+3	9E-7	3E-9	–	–
43	Technetium-97m	D, see ^{93m}Tc	5E+3	7E+3	3E-6	–	6E-5	6E-4
			–	St wall (7E+3)	–	1E-8	–	–
		W, see ^{93m}Tc	–	1E+3	5E-7	2E-9	–	–
43	Technetium-97	D, see ^{93m}Tc	4E+4	5E+4	2E-5	7E-8	5E-4	5E-3
		W, see ^{93m}Tc	–	6E+3	2E-6	8E-9	–	–
43	Technetium-98	D, see ^{93m}Tc	1E+3	2E+3	7E-7	2E-9	1E-5	1E-4
		W, see ^{93m}Tc	–	3E+2	1E-7	4E-10	–	–
43	Technetium-99m	D, see ^{93m}Tc	8E+4	2E+5	6E-5	2E-7	1E-3	1E-2
		W, see ^{93m}Tc	–	2E+5	1E-4	3E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

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

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
45	Rhodium-101m	D, see ^{99m}Rh	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, see ^{99m}Rh	–	8E+3	4E-6	1E-8	–	–
		Y, see ^{99m}Rh	–	8E+3	3E-6	1E-8	–	–
45	Rhodium-101	D, see ^{99m}Rh	2E+3	5E+2	2E-7	7E-10	3E-5	3E-4
		W, see ^{99m}Rh	–	8E+2	3E-7	1E-9	–	–
		Y, see ^{99m}Rh	–	2E+2	6E-8	2E-10	–	–
45	Rhodium-102m	D, see ^{99m}Rh	1E+3	5E+2	2E-7	7E-10	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		W, see ^{99m}Rh	–	4E+2	2E-7	5E-10	–	–
		Y, see ^{99m}Rh	–	1E+2	5E-8	2E-10	–	–
45	Rhodium-102	D, see ^{99m}Rh	6E+2	9E+1	4E-8	1E-10	8E-6	8E-5
		W, see ^{99m}Rh	–	2E+2	7E-8	2E-10	–	–
		Y, see ^{99m}Rh	–	6E+1	2E-8	8E-11	–	–
45	Rhodium-103m[b/]	D, see ^{99m}Rh	4E+5	1E+6	5E-4	2E-6	6E-3	6E-2
		W, see ^{99m}Rh	–	1E+6	5E-4	2E-6	–	–
		Y, see ^{99m}Rh	–	1E+6	5E-4	2E-6	–	–
45	Rhodium-105	D, see ^{99m}Rh	4E+3	1E+4	5E-6	2E-8	–	–
			LLI wall (4E+3)	–	–	–	5E-5	5E-4
		W, see ^{99m}Rh	–	6E+3	3E-6	9E-9	–	–
		Y, see ^{99m}Rh	–	6E+3	2E-6	8E-9	–	–
45	Rhodium-106m	D, see ^{99m}Rh	8E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, see ^{99m}Rh	–	4E+4	2E-5	5E-8	–	–
		Y, see ^{99m}Rh	–	4E+4	1E-5	5E-8	–	–
45	Rhodium-107[b/]	D, see ^{99m}Rh	7E+4	2E+5	1E-4	3E-7	–	–
			St wall (9E+4)	–	–	–	1E-3	1E-2
		W, see ^{99m}Rh	–	3E+5	1E-4	4E-7	–	–
		Y, see ^{99m}Rh	–	3E+5	1E-4	3E-7	–	–
46	Palladium-100	D, all compound44s except those given for W and4 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 ^{100}Pd	1E+4	3E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{100}Pd	–	3E+4	1E-5	5E-8	–	–
		Y, see ^{100}Pd	–	3E+4	1E-5	4E-8	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
46	Palladium-103	D, see ^{100}Pd	6E+3	6E+3	3E-6	9E-9	–	–
			LLI wall (7E+3)	–	–	–	1E-4	1E-3
		W, see ^{100}Pd	–	4E+3	2E-6	6E-9	–	–
		Y, see ^{100}Pd	–	4E+3	1E-6	5E-9	–	–
46	Palladium-107	D, see ^{100}Pd	3E+4	2E+4	9E-6	–	–	–
			LLI wall (4E+4)	Kidneys (2E+4)	–	3E-8	5E-4	5E-3
		W, see ^{100}Pd	–	7E+3	3E-6	1E-8	–	–
		Y, see ^{100}Pd	–	4E+2	2E-7	6E-10	–	–
46	Palladium-109	D, see ^{100}Pd	2E+3	6E+3	3E-6	9E-9	3E-5	3E-4
		W, see ^{100}Pd	–	5E+3	2E-6	8E-9	–	–
		Y, see ^{100}Pd	–	5E+3	2E-6	6E-9	–	–
47	Silver-102[b/]	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[b/]	D, see ^{102}Ag	4E+4	1E+5	4E-5	1E-7	5E-4	5E-3
		W, see ^{102}Ag	–	1E+5	5E-5	2E-7	–	–
		Y, see ^{102}Ag	–	1E+5	5E-5	2E-7	–	–
47	Silver-104m[b/]	D, see ^{102}Ag	3E+4	9E+4	4E-5	1E-7	4E-4	4E-3
		W, see ^{102}Ag	–	1E+5	5E-5	2E-7	–	–
		Y, see ^{102}Ag	–	1E+5	5E-5	2E-7	–	–
47	Silver-104[b/]	D, see ^{102}Ag	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{102}Ag	–	1E+5	6E-5	2E-7	–	–
		Y, see ^{102}Ag	–	1E+5	6E-5	2E-7	–	–
47	Silver-105	D, see ^{102}Ag	3E+3	1E+3	4E-7	1E-9	4E-5	4E-4
		W, see ^{102}Ag	–	2E+3	7E-7	2E-9	–	–
		Y, see ^{102}Ag	–	2E+3	7E-7	2E-9	–	–
47	Silver-106m	D, see ^{102}Ag	8E+2	7E+2	3E-7	1E-9	1E-5	1E-4
		W, see ^{102}Ag	–	9E+2	4E-7	1E-9	–	–
		Y, see ^{102}Ag	–	9E+2	4E-7	1E-9	–	–
47	Silver-106[b/]	D, see ^{102}Ag	6E+4	2E+5	8E-5	3E-7	–	–
			St wall (6E+4)	–	–	–	9E-4	9E-3
		W, see ^{102}Ag	–	2E+5	9E-5	3E-7	–	–
		Y, see ^{102}Ag	–	2E+5	8E-5	3E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
47	Silver-108m	D, see ^{102}Ag	6E+2	2E+2	8E-8	3E-10	9E-6	9E-5
		W, see ^{102}Ag	–	3E+2	1E-7	4E-10	–	–
		Y, see ^{102}Ag	–	2E+1	1E-8	3E-11	–	–
47	Silver-110m	D, see ^{102}Ag	5E+2	1E+2	5E-8	2E-10	6E-6	6E-5
		W, see ^{102}Ag	–	2E+2	8E-8	3E-10	–	–
		Y, see ^{102}Ag	–	9E+1	4E-8	1E-10	–	–
47	Silver-111	D, see ^{102}Ag	9E+2	2E+3	6E-7	–	–	–
			LLI wall	Liver				
			(1E+3)	(2E+3)	–	2E-9	2E-5	2E-4
		W, see ^{102}Ag	–	9E+2	4E-7	1E-9	–	–
		Y, see ^{102}Ag	–	9E+2	4E-7	1E-9	–	–
47	Silver-112	D, see ^{102}Ag	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{102}Ag	–	1E+4	4E-6	1E-8	–	–
		Y, see ^{102}Ag	–	9E+3	4E-6	1E-8	–	–
47	Silver-115[b/]	D, see ^{102}Ag	3E+4	9E+4	4E-5	1E-7	–	–
			St wall					
			(3E+4)	–	–	–	4E-4	4E-3
		W, see ^{102}Ag	–	9E+4	4E-5	1E-7	–	–
		Y, see ^{102}Ag	–	8E+4	3E-5	1E-7	–	–
48	Cadmium-104[b/]	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 ^{104}Cd	2E+4	5E+4	2E-5	8E-8	3E-4	3E-3
		W, see ^{104}Cd	–	6E+4	2E-5	8E-8	–	–
		Y, see ^{104}Cd	–	5E+4	2E-5	7E-8	–	–
48	Cadmium-109	D, see ^{104}Cd	3E+2	4E+1	1E-8	–	–	–
			Kidneys	Kidneys				
			(4E+2)	(5E+1)	–	7E-11	6E-6	6E-5
		W, see ^{104}Cd	–	1E+2	5E-8	–	–	–
			–	Kidneys (1E+2)	–	2E-10	–	–
		Y, see ^{104}Cd	–	1E+2	5E-8	2E-10	–	–
48	Cadmium-113m	D, see ^{104}Cd	2E+1	2E+0	1E-9	–	–	–
			Kidneys	Kidneys				
			(4E+1)	(4E+0)	–	5E-12	5E-7	5E-6
		W, see ^{104}Cd	–	8E+0	4E-9	–	–	–
			–	Kidneys (1E+1)	–	2E-11	–	–
		Y, see ^{104}Cd	–	1E+1	5E-9	2E-11	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

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

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values: Col. 1 Oral Ingestion ALI (µCi)	Table I Occupational Values: Inhalation Col. 2 ALI (µCi)	Table I Occupational Values: Inhalation Col. 3 DAC (µCi/ml)	Table II Effluent Concentrations: Col. 1 Air (µCi/ml)	Table II Effluent Concentrations: Col. 2 Water (µCi/ml)	Table III Releases to Sewers: Monthly Average Concentration (µCi/ml)
49	Indium-114m	D, see ^{109}In	3E+2	6E+1	3E-8	9E-11	–	–
			LLI wall (4E+2)	–	–	–	5E-6	5E-5
		W, see ^{109}In	–	1E+2	4E-8	1E-10	–	–
49	Indium-115m	D, see ^{109}In	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{109}In	–	5E+4	2E-5	7E-8	–	–
49	Indium-115	D, see ^{109}In	4E+1	1E+0	6E-10	2E-12	5E-7	5E-6
		W, see ^{109}In	–	5E+0	2E-9	8E-12	–	–
49	Indium-116m[b/]	D, see ^{109}In	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{109}In	–	1E+5	5E-5	2E-7	–	–
49	Indium-117m[b/]	D, see ^{109}In	1E+4	3E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{109}In	–	4E+4	2E-5	6E-8	–	–
49	Indium-117[b/]	D, see ^{109}In	6E+4	2E+5	7E-5	2E-7	8E-4	8E-3
		W, see ^{109}In	–	2E+5	9E-5	3E-7	–	–
49	Indium-119m[b/]	D, see ^{109}In	4E+4	1E+5	5E-5	2E-7	–	–
			St wall (5E+4)	–	–	–	7E-4	7E-3
		W, see ^{109}In	–	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[b/]	D, see ^{110}Sn	7E+4	2E+5	9E-5	3E-7	1E-3	1E-2
		W, see ^{110}Sn	–	3E+5	1E-4	4E-7	–	–
50	Tin-113	D, see ^{110}Sn	2E+3	1E+3	5E-7	2E-9	–	–
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
		W, see ^{110}Sn	–	5E+2	2E-7	8E-10	–	–
50	Tin-117m	D, see ^{110}Sn	2E+3	1E+3	5E-7	–	–	–
			LLI wall (2E+3)	Bone surf (2E+3)	–	3E-9	3E-5	3E-4
		W, see ^{110}Sn	–	1E+3	6E-7	2E-9	–	–
50	Tin-119m	D, see ^{110}Sn	3E+3	2E+3	1E-6	3E-9	–	–
			LLI wall (4E+3)	–	–	–	6E-5	6E-4
		W, see ^{110}Sn	–	1E+3	4E-7	1E-9	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
50	Tin-121m	D, see ^{110}Sn	3E+3	9E+2	4E-7	1E-9	–	–
			LLI wall (4E+3)	–	–	–	5E-5	5E-4
		W, see ^{110}Sn	–	5E+2	2E-7	8E-10	–	–
50	Tin-121	D, see ^{110}Sn	6E+3	2E+4	6E-6	2E-8	–	–
			LLI wall (6E+3)	–	–	–	8E-5	8E-4
		W, see ^{110}Sn	–	1E+4	5E-6	2E-8	–	–
50	Tin-123m[b/]	D, see ^{110}Sn	5E+4	1E+5	5E-5	2E-7	7E-4	7E-3
		W, see ^{110}Sn	–	1E+5	6E-5	2E-7	–	–
50	Tin-123	D, see ^{110}Sn	5E+2	6E+2	3E-7	9E-10	–	–
			LLI wall (6E+2)	–	–	–	9E-6	9E-5
		W, see ^{110}Sn	–	2E+2	7E-8	2E-10	–	–
50	Tin-125	D, see ^{110}Sn	4E+2	9E+2	4E-7	1E-9	–	–
			LLI wall (5E+2)	–	–	–	6E-6	6E-5
		W, see ^{110}Sn	–	4E+2	1E-7	5E-10	–	–
50	Tin-126	D, see ^{110}Sn	3E+2	6E+1	2E-8	8E-11	4E-6	4E-5
		W, see ^{110}Sn	–	7E+1	3E-8	9E-11	–	–
50	Tin-127	D, see ^{110}Sn	7E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		W, see ^{110}Sn	–	2E+4	8E-6	3E-8	–	–
50	Tin-128[b/]	D, see ^{110}Sn	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, see ^{110}Sn	–	4E+4	1E-5	5E-8	–	–
51	Antimony-115[b/]	D, all compounds except those given for W	8E+4	2E+5	1E-4	3E-7	1E-3	1E-2
		W, oxides, hydroxides, halides, sulfides, sulfates, and nitrates	–	3E+5	1E-4	4E-7	–	–
51	Antimony-116m[b/]	D, see ^{115}Sb	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{115}Sb	–	1E+5	6E-5	2E-7	–	–
51	Antimony-116[b/]	D, see ^{115}Sb	7E+4	3E+5	1E-4	4E-7	–	–
			St wall (9E+4)	–	–	–	1E-3	1E-2
		W, see ^{115}Sb	–	3E+5	1E-4	5E-7	–	–
51	Antimony-117	D, see ^{115}Sb	7E+4	2E+5	9E-5	3E-7	9E-4	9E-3
		W, see ^{115}Sb	–	3E+5	1E-4	4E-7	–	–
51	Antimony-118m	D, see ^{115}Sb	6E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		W, see ^{115}Sb	5E+3	2E+4	9E-6	3E-8	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
51	Antimony-119	D, see ^{115}Sb	2E+4	5E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{115}Sb	2E+4	3E+4	1E-5	4E-8	–	–
51	Antimony-120[b/] (16 min)	D, see ^{115}Sb	1E+5 St wall (2E+5)	4E+5	2E-4	6E-7	–	–
				–	–	–	2E-3	2E-2
		W, see ^{115}Sb	–	5E+5	2E-4	7E-7	–	–
51	Antimony-120 (5.76 d)	D, see ^{115}Sb	1E+3	2E+3	9E-7	3E-9	1E-5	1E-4
		W, see ^{115}Sb	9E+2	1E+3	5E-7	2E-9	–	–
51	Antimony-122	D, see ^{115}Sb	8E+2 LLI wall (8E+2)	2E+3	1E-6	3E-9	–	–
				–	–	–	1E-5	1E-4
		W, see ^{115}Sb	7E+2	1E+3	4E-7	2E-9	–	–
51	Antimony-124m[b/]	D, see ^{115}Sb	3E+5	8E+5	4E-4	1E-6	3E-3	3E-2
		W, see ^{115}Sb	2E+5	6E+5	2E-4	8E-7	–	–
51	Antimony-124	D, see ^{115}Sb	6E+2	9E+2	4E-7	1E-9	7E-6	7E-5
		W, see ^{115}Sb	5E+2	2E+2	1E-7	3E-10	–	–
51	Antimony-125	D, see ^{115}Sb	2E+3	2E+3	1E-6	3E-9	3E-5	3E-4
		W, see ^{115}Sb	–	5E+2	2E-7	7E-10	–	–
51	Antimony-126m[b/]	D, see ^{115}Sb	5E+4 St wall (7E+4)	2E+5	8E-5	3E-7	–	–
				–	–	–	9E-4	9E-3
		W, see ^{115}Sb	–	2E+5	8E-5	3E-7	–	–
51	Antimony-126	D, see ^{115}Sb	6E+2	1E+3	5E-7	2E-9	7E-6	7E-5
		W, see ^{115}Sb	5E+2	5E+2	2E-7	7E-10	–	–
51	Antimony-127	D, see ^{115}Sb	8E+2 LLI wall (8E+2)	2E+3	9E-7	3E-9	–	–
				–	–	–	1E-5	1E-4
		W, see ^{115}Sb	7E+2	9E+2	4E-7	1E-9	–	–
51	Antimony-128[b/] (10.4 min)	D, see ^{115}Sb	8E+4 St wall (1E+5)	4E+5	2E-4	5E-7	–	–
				–	–	–	1E-3	1E-2
		W, see ^{115}Sb	–	4E+5	2E-4	6E-7	–	–
51	Antimony-128 (9.01 h)	D, see ^{115}Sb	1E+3	4E+3	2E-6	6E-9	2E-5	2E-4
		W, see ^{115}Sb	–	3E+3	1E-6	5E-9	–	–
51	Antimony-129	D, see ^{115}Sb	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		W, see ^{115}Sb	–	9E+3	4E-6	1E-8	–	–
51	Antimony-130[b/]	D, see ^{115}Sb	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		W, see ^{115}Sb	–	8E+4	3E-5	1E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
51	Antimony-131[b/]	D, see ^{115}Sb	1E+4 Thyroid	2E+4 Thyroid	1E-5	–	–	–
			(2E+4)	(4E+4)	–	6E-8	2E-4	2E-3
		W, see ^{115}Sb	-	2E+4 Thyroid	1E-5	–	–	–
			-	(4E+4)	–	6E-8	–	–
52	Tellurium-116	D, all compounds except those given for W	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, oxides, hydroxides, and nitrates	-	3E+4	1E-5	4E-8	–	–
52	Tellurium-121m	D, see ^{116}Te	5E+2 Bone surf	2E+2 Bone surf	8E-8	–	–	–
			(7E+2)	(4E+2)	–	5E-10	1E-5	1E-4
		W, see ^{116}Te	–	4E+2	2E-7	6E-10	–	–
52	Tellurium-121	D, see ^{116}Te	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
		W, see ^{116}Te	–	3E+3	1E-6	4E-9	–	–
52	Tellurium-123m	D, see ^{116}Te	6E+2 Bone surf	2E+2 Bone surf	9E-8	–	–	–
			(1E+3)	(5E+2)	–	8E-10	1E-5	1E-4
		W, see ^{116}Te	–	5E+2	2E-7	8E-10	–	–
52	Tellurium-123	D, see ^{116}Te	5E+2 Bone surf	2E+2 Bone surf	8E-8	–	–	–
			(1E+3)	(5E+2)	–	7E-10	2E-5	2E-4
		W, see ^{116}Te	–	4E+2 Bone surf	2E-7	–	–	–
			–	(1E+3)	–	2E-9	–	–
52	Tellurium-125m	D, see ^{116}Te	1E+3 Bone surf	4E+2 Bone surf	2E-7	–	–	–
			(1E+3)	(1E+3)	–	1E-9	2E-5	2E-4
		W, see ^{116}Te	–	7E+2	3E-7	1E-9	–	–
52	Tellurium-127m	D, see ^{116}Te	6E+2	3E+2 Bone surf	1E-7	–	9E-6	9E-5
			–	(4E+2)	–	6E-10	–	–
		W, see ^{116}Te	–	3E+2	1E-7	4E-10	–	–
52	Tellurium-127	D, see ^{116}Te	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{116}Te	–	2E+4	7E-6	2E-8	–	–
52	Tellurium-129m	D, see ^{116}Te	5E+2	6E+2	3E-7	9E-10	7E-6	7E-5
		W, see ^{116}Te	–	2E+2	1E-7	3E-10	–	–
52	Tellurium-129[b/]	D, see ^{116}Te	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
		W, see ^{116}Te	–	7E+4	3E-5	1E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
52	Tellurium-131m	D, see ^{116}Te	3E+2 Thyroid (6E+2)	4E+2 Thyroid (1E+3)	2E-7 –	– 2E-9	– 8E-6	– 8E-5
		W, see ^{116}Te	– –	4E+2 Thyroid (9E+2)	2E-7 –	– 1E-9	– –	– –
52	Tellurium-131[b/]	D, see ^{116}Te	3E+3 Thyroid (6E+3)	5E+3 Thyroid (1E+4)	2E-6 –	– 2E-8	– 8E-5	– 8E-4
		W, see ^{116}Te	– –	5E+3 Thyroid (1E+4)	2E-6 –	– 2E-8	– –	– –
52	Tellurium-132	D, see ^{116}Te	2E+2 Thyroid (7E+2)	2E+2 Thyroid (8E+2)	9E-8 –	– 1E-9	– 9E-6	– 9E-5
		W, see ^{116}Te	– –	2E+2 Thyroid (6E+2)	9E-8 –	– 9E-10	– –	– –
52	Tellurium-133m[b/]	D, see ^{116}Te	3E+3 Thyroid (6E+3)	5E+3 Thyroid (1E+4)	2E-6 –	– 2E-8	– 9E-5	– 9E-4
		W, see ^{116}Te	– –	5E+3 Thyroid (1E+4)	2E-6 –	– 2E-8	– –	– –
52	Tellurium-133[b/]	D, see ^{116}Te	1E+4 Thyroid (3E+4)	2E+4 Thyroid (6E+4)	9E-6 –	– 8E-8	– 4E-4	– 4E-3
		W, see ^{116}Te	– –	2E+4 Thyroid (6E+4)	9E-6 –	– 8E-8	– –	– –
52	Tellurium-134[b/]	D, see ^{116}Te	2E+4 Thyroid (2E+4)	2E+4 Thyroid (5E+4)	1E-5 –	– 7E-8	– 3E-4	– 3E-3
		W, see ^{116}Te	– –	2E+4 Thyroid (5E+4)	1E-5 –	– 7E-8	– –	– –
53	Iodine-120m[b/]	D, all compounds	1E+4 Thyroid (1E+4)	2E+4 –	9E-6 –	3E-8 –	– 2E-4	– 2E-3
53	Iodine-120[b/]	D, all compounds	4E+3 Thyroid (8E+3)	9E+3 Thyroid (1E+4)	4E-6 –	– 2E-8	– 1E-4	– 1E-3

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
53	Iodine-121	D, all compounds	1E+4 Thyroid (3E+4)	2E+4 Thyroid (5E+4)	8E-6 –	– 7E-8	– 4E-4	– 4E-3
53	Iodine-123	D, all compounds	3E+3 Thyroid (1E+4)	6E+3 Thyroid (2E+4)	3E-6 –	– 2E-8	– 1E-4	– 1E-3
53	Iodine-124	D, all compounds	5E+1 Thyroid (2E+2)	8E+1 Thyroid (3E+2)	3E-8 –	– 4E-10	– 2E-6	– 2E-5
53	Iodine-125	D, all compounds	4E+1 Thyroid (1E+2)	6E+1 Thyroid (2E+2)	3E-8 –	– 3E-10	– 2E-6	– 2E-5
53	Iodine-126	D, all compounds	2E+1 Thyroid (7E+1)	4E+1 Thyroid (1E+2)	1E-8 –	– 2E-10	– 1E-6	– 1E-5
53	Iodine-128[b/]	D, all compounds	4E+4 St wall (6E+4)	1E+5 –	5E-5 –	2E-7 –	– 8E-4	– 8E-3
53	Iodine-129	D, all compounds	5E+0 Thyroid (2E+1)	9E+0 Thyroid (3E+1)	4E-9 –	– 4E-11	– 2E-7	– 2E-6
53	Iodine-130	D, all compounds	4E+2 Thyroid (1E+3)	7E+2 Thyroid (2E+3)	3E-7 –	– 3E-9	– 2E-5	– 2E-4
53	Iodine-131	D, all compounds	3E+1 Thyroid (9E+1)	5E+1 Thyroid (2E+2)	2E-8 –	– 2E-10	– 1E-6	– 1E-5
53	Iodine-132m[b/]	D, all compounds	4E+3 Thyroid (1E+4)	8E+3 Thyroid (2E+4)	4E-6 –	– 3E-8	– 1E-4	– 1E-3
53	Iodine-132	D, all compounds	4E+3 Thyroid (9E+3)	8E+3 Thyroid (1E+4)	3E-6 –	– 2E-8	– 1E-4	– 1E-3
53	Iodine-133	D, all compounds	1E+2 Thyroid (5E+2)	3E+2 Thyroid (9E+2)	1E-7 –	– 1E-9	– 7E-6	– 7E-5
53	Iodine-134[b/]	D, all compounds	2E+4 Thyroid (3E+4)	5E+4 –	2E-5 –	6E-8 –	– 4E-4	– 4E-3

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
53	Iodine-135	D, all compounds	8E+2 Thyroid (3E+3)	2E+3 Thyroid (4E+3)	7E-7 –	– 6E-9	– 3E-5	– 3E-4
54	Xenon-120[b/]	Submersion[a/]	–	–	1E-5	4E-8	–	–
54	Xenon-121[b/]	Submersion[a/]	–	–	2E-6	1E-8	–	–
54	Xenon-122	Submersion[a/]	–	–	7E-5	3E-7	–	–
54	Xenon-123	Submersion[a/]	–	–	6E-6	3E-8	–	–
54	Xenon-125	Submersion[a/]	–	–	2E-5	7E-8	–	–
54	Xenon-127	Submersion[a/]	–	–	1E-5	6E-8	–	–
54	Xenon-129m	Submersion[a/]	–	–	2E-4	9E-7	–	–
54	Xenon-131m	Submersion[a/]	–	–	4E-4	2E-6	–	–
54	Xenon-133m	Submersion[a/]	–	–	1E-4	6E-7	–	–
54	Xenon-133	Submersion[a/]	–	–	1E-4	5E-7	–	–
54	Xenon-135m[b/]	Submersion[a/]	–	–	9E-6	4E-8	–	–
54	Xenon-135	Submersion[a/]	–	–	1E-5	7E-8	–	–
54	Xenon-138[b/]	Submersion[a/]	–	–	4E-6	2E-8	–	–
55	Cesium-125[b/]	D, all compounds	5E+4 St wall (9E+4)	1E+5 –	6E-5 –	2E-7 –	– 1E-3	– 1E-2
55	Cesium-127	D, all compounds	6E+4	9E+4	4E-5	1E-7	9E-4	9E-3
55	Cesium-129	D, all compounds	2E+4	3E+4	1E-5	5E-8	3E-4	3E-3
55	Cesium-130[b/]	D, all compounds	6E+4 St wall (1E+5)	2E+5 –	8E-5 –	3E-7 –	– 1E-3	– 1E-2
55	Cesium-131	D, all compounds	2E+4	3E+4	1E-5	4E-8	3E-4	3E-3
55	Cesium-132	D, all compounds	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
55	Cesium-134m	D, all compounds	1E+5 St wall (1E+5)	1E+5 –	6E-5 –	2E-7 –	– 2E-3	– 2E-2
55	Cesium-134	D, all compounds	7E+1	1E+2	4E-8	2E-10	9E-7	9E-6

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
55	Cesium-135m[b/]	D, all compounds	1E+5	2E+5	8E-5	3E-7	1E-3	1E-2
55	Cesium-135	D, all compounds	7E+2	1E+3	5E-7	2E-9	1E-5	1E-4
55	Cesium-136	D, all compounds	4E+2	7E+2	3E-7	9E-10	6E-6	6E-5
55	Cesium-137	D, all compounds	1E+2	2E+2	6E-8	2E-10	1E-6	1E-5
55	Cesium-138[b/]	D, all compounds	2E+4	6E+4	2E-5	8E-8	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
56	Barium-126[b/]	D, all compounds	6E+3	2E+4	6E-6	2E-8	8E-5	8E-4
56	Barium-128	D, all compounds	5E+2	2E+3	7E-7	2E-9	7E-6	7E-5
56	Barium-131m[b/]	D, all compounds	4E+5	1E+6	6E-4	2E-6	–	–
			St wall (5E+5)	–	–	–	7E-3	7E-2
56	Barium-131	D, all compounds	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
56	Barium-133m	D, all compounds	2E+3	9E+3	4E-6	1E-8	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
56	Barium-133	D, all compounds	2E+3	7E+2	3E-7	9E-10	2E-5	2E-4
56	Barium-135m	D, all compounds	3E+3	1E+4	5E-6	2E-8	4E-5	4E-4
56	Barium-139[b/]	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[b/]	D, all compounds	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
56	Barium-142[b/]	D, all compounds	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
57	Lanthanum-131[b/]	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 ^{131}La	3E+3	1E+4	4E-6	1E-8	4E-5	4E-4
		W, see ^{131}La	–	1E+4	5E-6	2E-8	–	–
57	Lanthanum-135	D, see ^{131}La	4E+4	1E+5	4E-5	1E-7	5E-4	5E-3
		W, see ^{131}La	–	9E+4	4E-5	1E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
57	Lanthanum-137	D, see ^{131}La	1E+4	6E+1	3E-8	–	2E-4	2E-3
				Liver				
			–	(7E+1)	–	1E-10	–	–
		W, see ^{131}La	–	3E+2	1E-7	–	–	–
				Liver				
			–	(3E+2)	–	4E-10	–	–
57	Lanthanum-138	D, see ^{131}La	9E+2	4E+0	1E-9	5E-12	1E-5	1E-4
		W, see ^{131}La	–	1E+1	6E-9	2E-11	–	–
57	Lanthanum-140	D, see ^{131}La	6E+2	1E+3	6E-7	2E-9	9E-6	9E-5
		W, see ^{131}La	–	1E+3	5E-7	2E-9	–	–
57	Lanthanum-141	D, see ^{131}La	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
		W, see ^{131}La	–	1E+4	5E-6	2E-8	–	–
57	Lanthanum-142[b/]	D, see ^{131}La	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{131}La	–	3E+4	1E-5	5E-8	–	–
57	Lanthanum-143[b/]	D, see ^{131}La	4E+4	1E+5	4E-5	1E-7	–	–
			St wall					
			(4E+4)	–	–	–	5E-4	5E-3
		W, see ^{131}La	–	9E+4	4E-5	1E-7	–	–
58	Cerium-134	W, all compounds except those given for Y	5E+2	7E+2	3E-7	1E-9	–	–
			LLI wall					
			(6E+2)	–	–	–	8E-6	8E-5
		Y, oxides, hydroxides, and fluorides	–	7E+2	3E-7	9E-10	–	–
58	Cerium-135	W, see ^{134}Ce	2E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		Y, see ^{134}Ce	–	4E+3	1E-6	5E-9	–	–
58	Cerium-137m	W, see ^{134}Ce	2E+3	4E+3	2E-6	6E-9	–	–
			LLI wall					
			(2E+3)	–	–	–	3E-5	3E-4
		Y, see ^{134}Ce	–	4E+3	2E-6	5E-9	–	–
58	Cerium-137	W, see ^{134}Ce	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
		Y, see ^{134}Ce	–	1E+5	5E-5	2E-7	–	–
58	Cerium-139	W, see ^{134}Ce	5E+3	8E+2	3E-7	1E-9	7E-5	7E-4
		Y, see ^{134}Ce	–	7E+2	3E-7	9E-10	–	–
58	Cerium-141	W, see ^{134}Ce	2E+3	7E+2	3E-7	1E-9	–	–
			LLI wall					
			(2E+3)	–	–	–	3E-5	3E-4
		Y, see ^{134}Ce	–	6E+2	2E-7	8E-10	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
58	Cerium-143	W, see ^{134}Ce	1E+3	2E+3	8E-7	3E-9	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{134}Ce	–	2E+3	7E-7	2E-9	–	–
58	Cerium-144	W, see ^{134}Ce	2E+2	3E+1	1E-8	4E-11	–	–
			LLI wall (3E+2)	–	–	–	3E-6	3E-5
		Y, see ^{134}Ce	–	1E+1	6E-9	2E-11	–	–
59	Praseodymium-136[b/]	W, all compounds except those given for Y	5E+4	2E+5	1E-4	3E-7	–	–
			St wall (7E+4)	–	–	–	1E-3	1E-2
		Y, oxides, hydroxides, carbides, and fluorides	–	2E+5	9E-5	3E-7	–	–
59	Praseodymium-137[b/]	W, see ^{136}Pr	4E+4	2E+5	6E-5	2E-7	5E-4	5E-3
		Y, see ^{136}Pr	–	1E+5	6E-5	2E-7	–	–
59	Praseodymium-138m	W, see ^{136}Pr	1E+4	5E+4	2E-5	8E-8	1E-4	1E-3
		Y, see ^{136}Pr	–	4E+4	2E-5	6E-8	–	–
59	Praseodymium-139	W, see ^{136}Pr	4E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		Y, see ^{136}Pr	–	1E+5	5E-5	2E-7	–	–
59	Praseodymium-142m[b/]	W, see ^{136}Pr	8E+4	2E+5	7E-5	2E-7	1E-3	1E-2
		Y, see ^{136}Pr	–	1E+5	6E-5	2E-7	–	–
59	Praseodymium-142	W, see ^{136}Pr	1E+3	2E+3	9E-7	3E-9	1E-5	1E-4
		Y, see ^{136}Pr	–	2E+3	8E-7	3E-9	–	–
59	Praseodymium-143	W, see ^{136}Pr	9E+2	8E+2	3E-7	1E-9	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{136}Pr	–	7E+2	3E-7	9E-10	–	–
59	Praseodymium-144[b/]	W, see ^{136}Pr	3E+4	1E+5	5E-5	2E-7	–	–
			St wall (4E+4)	–	–	–	6E-4	6E-3
		Y, see ^{136}Pr	–	1E+5	5E-5	2E-7	–	–
59	Praseodymium-145	W, see ^{136}Pr	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{136}Pr	–	8E+3	3E-6	1E-8	–	–
59	Praseodymium-147[b/]	W, see ^{136}Pr	5E+4	2E+5	8E-5	3E-7	–	–
			St wall (8E+4)	–	–	–	1E-3	1E-2
		Y, see ^{136}Pr	–	2E+5	8E-5	3E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
60	Neodymium-136[b/]	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 ^{136}Nd	2E+3	6E+3	3E-6	9E-9	3E-5	3E-4
		Y, see ^{136}Nd	-	5E+3	2E-6	7E-9	-	-
60	Neodymium-139m	W, see ^{136}Nd	5E+3	2E+4	7E-6	2E-8	7E-5	7E-4
		Y, see ^{136}Nd	–	1E+4	6E-6	2E-8	–	–
60	Neodymium-139[b/]	W, see ^{136}Nd	9E+4	3E+5	1E-4	5E-7	1E-3	1E-2
		Y, see ^{136}Nd	–	3E+5	1E-4	4E-7	–	–
60	Neodymium-141	W, see ^{136}Nd	2E+5	7E+5	3E-4	1E-6	2E-3	2E-2
		Y, see ^{136}Nd	–	6E+5	3E-4	9E-7	–	–
60	Neodymium-147	W, see ^{136}Nd	1E+3	9E+2	4E-7	1E-9	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{136}Nd	–	8E+2	4E-7	1E-9	–	–
60	Neodymium-149[b/]	W, see ^{136}Nd	1E+4	3E+4	1E-5	4E-8	1E-4	1E-3
		Y, see ^{136}Nd	–	2E+4	1E-5	3E-8	–	–
60	Neodymium-151[b/]	W, see ^{136}Nd	7E+4	2E+5	8E-5	3E-7	9E-4	9E-3
		Y, see ^{136}Nd	–	2E+5	8E-5	3E-7	–	–
61	Promethium-141[b/]	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 ^{141}Pm	5E+3	6E+2	2E-7	8E-10	7E-5	7E-4
		Y, see ^{141}Pm	–	7E+2	3E-7	1E-9	–	–
61	Promethium-144	W, see ^{141}Pm	1E+3	1E+2	5E-8	2E-10	2E-5	2E-4
		Y, see ^{141}Pm	–	1E+2	5E-8	2E-10	–	–
61	Promethium-145	W, see ^{141}Pm	1E+4	2E+2	7E-8	–	1E-4	1E-3
			–	Bone surf (2E+2)	–	3E-10	–	–
		Y, see ^{141}Pm	–	2E+2	8E-8	3E-10	–	–
61	Promethium-146	W, see ^{141}Pm	2E+3	5E+1	2E-8	7E-11	2E-5	2E-4
		Y, see ^{141}Pm	–	4E+1	2E-8	6E-11	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
61	Promethium-147	W, see ^{141}Pm	4E+3	1E+2	5E-8	–	–	–
			LLI wall (5E+3)	Bone surf (2E+2)	–	3E-10	7E-5	7E-4
		Y, see ^{141}Pm	–	1E+2	6E-8	2E-10	–	–
61	Promethium-148m	W, see ^{141}Pm	7E+2	3E+2	1E-7	4E-10	1E-5	1E-4
		Y, see ^{141}Pm	–	3E+2	1E-7	5E-10	–	–
61	Promethium-148	W, see ^{141}Pm	4E+2	5E+2	2E-7	8E-10	–	–
			LLI wall (5E+2)	–	–	–	7E-6	7E-5
		Y, see ^{141}Pm	–	5E+2	2E-7	7E-10	–	–
61	Promethium-149	W, see ^{141}Pm	1E+3	2E+3	8E-7	3E-9	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{141}Pm	–	2E+3	8E-7	2E-9	–	–
61	Promethium-150	W, see ^{141}Pm	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		Y, see ^{141}Pm	–	2E+4	7E-6	2E-8	–	–
61	Promethium-151	W, see ^{141}Pm	2E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		Y, see ^{141}Pm	–	3E+3	1E-6	4E-9	–	–
62	Samarium-141m[b/]	W, all compounds	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
62	Samarium-141[b/]	W, all compounds	5E+4	2E+5	8E-5	2E-7	–	–
			St wall (6E+4)	–	–	–	8E-4	8E-3
62	Samarium-142[b/]	W, all compounds	8E+3	3E+4	1E-5	4E-8	1E-4	1E-3
62	Samarium-145	W, all compounds	6E+3	5E+2	2E-7	7E-10	8E-5	8E-4
62	Samarium-146	W, all compounds	1E+1	4E-2	1E-11	–	–	–
			Bone surf (3E+1)	Bone surf (6E-2)	–	9E-14	3E-7	3E-6
62	Samarium-147	W, all compounds	2E+1	4E-2	2E-11	–	–	–
			Bone surf (3E+1)	Bone surf (7E-2)	–	1E-13	4E-7	4E-6
62	Samarium-151	W, all compounds	1E+4	1E+2	4E-8	–	–	–
			LLI wall (1E+4)	Bone surf (2E+2)	–	2E-10	2E-4	2E-3
62	Samarium-153	W, all compounds	2E+3	3E+3	1E-6	4E-9	–	–
			LLI wall (2E+3)	–	–	–	3E-5	3E-4

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
62	Samarium-155[b/]	W, all compounds	6E+4	2E+5	9E-5	3E-7	–	–
			St wall (8E+4)	–	–	–	1E-3	1E-2
62	Samarium-156	W, all compounds	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
63	Europium-145	W, all compounds	2E+3	2E+3	8E-7	3E-9	2E-5	2E-4
63	Europium-146	W, all compounds	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
63	Europium-147	W, all compounds	3E+3	2E+3	7E-7	2E-9	4E-5	4E-4
63	Europium-148	W, all compounds	1E+3	4E+2	1E-7	5E-10	1E-5	1E-4
63	Europium-149	W, all compounds	1E+4	3E+3	1E-6	4E-9	2E-4	2E-3
63	Europium-150 (12.62 h)	W, all compounds	3E+3	8E+3	4E-6	1E-8	4E-5	4E-4
63	Europium-150 (34.2 y)	W, all compounds	8E+2	2E+1	8E-9	3E-11	1E-5	1E-4
63	Europium-152m	W, all compounds	3E+3	6E+3	3E-6	9E-9	4E-5	4E-4
63	Europium-152	W, all compounds	8E+2	2E+1	1E-8	3E-11	1E-5	1E-4
63	Europium-154	W, all compounds	5E+2	2E+1	8E-9	3E-11	7E-6	7E-5
63	Europium-155	W, all compounds	4E+3	9E+1	4E-8	–	5E-5	5E-4
			–	Bone surf (1E+2)	–	2E-10	–	–
63	Europium-156	W, all compounds	6E+2	5E+2	2E-7	6E-10	8E-6	8E-5
63	Europium-157	W, all compounds	2E+3	5E+3	2E-6	7E-9	3E-5	3E-4
63	Europium-158[b/]	W, all compounds	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
64	Gadolinium-145[b/]	D, all compounds except those given for W	5E+4	2E+5	6E-5	2E-7	–	–
			St wall (5E+4)	–	–	–	6E-4	6E-3
		W, oxides, hydroxides, and fluorides	–	2E+5	7E-5	2E-7	–	–
64	Gadolinium-146	D, see ^{145}Gd	1E+3	1E+2	5E-8	2E-10	2E-5	2E-4
		W, see ^{145}Gd	–	3E+2	1E-7	4E-10	–	–
64	Gadolinium-147	D, see ^{145}Gd	2E+3	4E+3	2E-6	6E-9	3E-5	3E-4
		W, see ^{145}Gd	–	4E+3	1E-6	5E-9	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

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

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
65	Terbium-157	W, all compounds	5E+4	3E+2	1E-7	–	–	–
			LLI wall (5E+4)	Bone surf (6E+2)	–	8E-10	7E-4	7E-3
65	Terbium-158	W, all compounds	1E+3	2E+1	8E-9	3E-11	2E-5	2E-4
65	Terbium-160	W, all compounds	8E+2	2E+2	9E-8	3E-10	1E-5	1E-4
65	Terbium-161	W, all compounds	2E+3	2E+3	7E-7	2E-9	–	–
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
66	Dysprosium-155	W, all compounds	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
66	Dysprosium-157	W, all compounds	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
66	Dysprosium-159	W, all compounds	1E+4	2E+3	1E-6	3E-9	2E-4	2E-3
66	Dysprosium-165	W, all compounds	1E+4	5E+4	2E-5	6E-8	2E-4	2E-3
66	Dysprosium-166	W, all compounds	6E+2	7E+2	3E-7	1E-9	–	–
			LLI wall (8E+2)	–	–	–	1E-5	1E-4
67	Holmium-155[b/]	W, all compounds	4E+4	2E+5	6E-5	2E-7	6E-4	6E-3
67	Holmium-157[b/]	W, all compounds	3E+5	1E+6	6E-4	2E-6	4E-3	4E-2
67	Holmium-159[b/]	W, all compounds	2E+5	1E+6	4E-4	1E-6	3E-3	3E-2
67	Holmium-161	W, all compounds	1E+5	4E+5	2E-4	6E-7	1E-3	1E-2
67	Holmium-162m[b/]	W, all compounds	5E+4	3E+5	1E-4	4E-7	7E-4	7E-3
67	Holmium-162[b/]	W, all compounds	5E+5	2E+6	1E-3	3E-6	–	–
			St wall (8E+5)	–	–	–	1E-2	1E-1
67	Holmium-164m[b/]	W, all compounds	1E+5	3E+5	1E-4	4E-7	1E-3	1E-2
67	Holmium-164[b/]	W, all compounds	2E+5	6E+5	3E-4	9E-7	–	–
			St wall (2E+5)	–	–	–	3E-3	3E-2
67	Holmium-166m	W, all compounds	6E+2	7E+0	3E-9	9E-12	9E-6	9E-5
67	Holmium-166	W, all compounds	9E+2	2E+3	7E-7	2E-9	–	–
			LLI wall (9E+2)	–	–	–	1E-5	1E-4
67	Holmium-167	W, all compounds	2E+4	6E+4	2E-5	8E-8	2E-4	2E-3

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
68	Erbium-161	W, all compounds	2E+4	6E+4	3E-5	9E-8	2E-4	2E-3
68	Erbium-165	W, all compounds	6E+4	2E+5	8E-5	3E-7	9E-4	9E-3
68	Erbium-169	W, all compounds	3E+3	3E+3	1E-6	4E-9	–	-
			LLI wall (4E+3)	–	–	–	5E-5	5E-4
68	Erbium-171	W, all compounds	4E+3	1E+4	4E-6	1E-8	5E-5	5E-4
68	Erbium-172	W, all compounds	1E+3	1E+3	6E-7	2E-9	–	-
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
69	Thulium-162[b/]	W, all compounds	7E+4	3E+5	1E-4	4E-7	–	-
			St wall (7E+4)	–	–	–	1E-3	1E-2
69	Thulium-166	W, all compounds	4E+3	1E+4	6E-6	2E-8	6E-5	6E-4
69	Thulium-167	W, all compounds	2E+3	2E+3	8E-7	3E-9	–	-
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
69	Thulium-170	W, all compounds	8E+2	2E+2	9E-8	3E-10	–	-
			LLI wall (1E+3)	–	–	–	1E-5	1E-4
69	Thulium-171	W, all compounds	1E+4	3E+2	1E-7	–	–	-
			LLI wall (1E+4)	Bone surf (6E+2)	–	8E-10	2E-4	2E-3
69	Thulium-172	W, all compounds	7E+2	1E+3	5E-7	2E-9	–	-
			LLI wall (8E+2)	–	–	–	1E-5	1E-4
69	Thulium-173	W, all compounds	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
69	Thulium-175[b/]	W, all compounds	7E+4	3E+5	1E-4	4E-7	–	-
			St wall (9E+4)	–	–	–	1E-3	1E-2
70	Ytterbium-162[b/]	W, all compounds except those given for Y	7E+4	3E+5	1E-4	4E-7	1E-3	1E-2
		Y, oxides, hydroxides, and fluorides	–	3E+5	1E-4	4E-7	–	-
70	Ytterbium-166	W, see ^{162}Yb	1E+3	2E+3	8E-7	3E-9	2E-5	2E-4
		Y, see ^{162}Yb	–	2E+3	8E-7	3E-9	–	-

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
70	Ytterbium-167[b/]	W, see ^{162}Yb	3E+5	8E+5	3E-4	1E-6	4E-3	4E-2
		Y, see ^{162}Yb	–	7E+5	3E-4	1E-6	–	–
70	Ytterbium-169	W, see ^{162}Yb	2E+3	8E+2	4E-7	1E-9	2E-5	2E-4
		Y, see ^{162}Yb	–	7E+2	3E-7	1E-9	–	–
70	Ytterbium-175	W, see ^{162}Yb	3E+3	4E+3	1E-6	5E-9	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
		Y, see ^{162}Yb	–	3E+3	1E-6	5E-9	–	–
70	Ytterbium-177[b/]	W, see ^{162}Yb	2E+4	5E+4	2E-5	7E-8	2E-4	2E-3
		Y, see ^{162}Yb	–	5E+4	2E-5	6E-8	–	–
70	Ytterbium-178[b/]	W, see ^{162}Yb	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		Y, see ^{162}Yb	–	4E+4	2E-5	5E-8	–	–
71	Lutetium-169	W, all compounds except those given for Y	3E+3	4E+3	2E-6	6E-9	3E-5	3E-4
		Y, oxides, hydroxides, and fluorides	–	4E+3	2E-6	6E-9	–	–
71	Lutetium-170	W, see ^{169}Lu	1E+3	2E+3	9E-7	3E-9	2E-5	2E-4
		Y, see ^{169}Lu	–	2E+3	8E-7	3E-9	–	–
71	Lutetium-171	W, see ^{169}Lu	2E+3	2E+3	8E-7	3E-9	3E-5	3E-4
		Y, see ^{169}Lu	–	2E+3	8E-7	3E-9	–	–
71	Lutetium-172	W, see ^{169}Lu	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
		Y, see ^{169}Lu	–	1E+3	5E-7	2E-9	–	–
71	Lutetium-173	W, see ^{169}Lu	5E+3	3E+2	1E-7	–	7E-5	7E-4
			–	Bone surf (5E+2)	-	6E-10	–	–
		Y, see ^{169}Lu	–	3E+2	1E-7	4E-10	–	–
71	Lutetium-174m	W, see ^{169}Lu	2E+3	2E+2	1E-7	–	–	–
			LLI wall (3E+3)	Bone surf (3E+2)	–	5E-10	4E-5	4E-4
		Y, see ^{169}Lu	–	2E+2	9E-8	3E-10	–	–
71	Lutetium-174	W, see ^{169}Lu	5E+3	1E+2	5E-8	–	7E-5	7E-4
			–	Bone surf (2E+2)	–	3E-10	–	–
		Y, see ^{169}Lu	–	2E+2	6E-8	2E-10	–	–
71	Lutetium-176m	W, see ^{169}Lu	8E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		Y, see ^{169}Lu	–	2E+4	9E-6	3E-8	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
71	Lutetium-176	W, see ^{169}Lu	7E+2	5E+0	2E-9	–	1E-5	1E-4
			–	Bone surf (1E+1)	–	2E-11	–	–
		Y, see ^{169}Lu	–	8E+0	3E-9	1E-11	–	–
71	Lutetium-177m	W, see ^{169}Lu	7E+2	1E+2	5E-8	–	1E-5	1E-4
			–	Bone surf (1E+2)	–	2E-10	–	–
		Y, see ^{169}Lu	–	8E+1	3E-8	1E-10	–	–
71	Lutetium-177	W, see ^{169}Lu	2E+3	2E+3	9E-7	3E-9	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
		Y, see ^{169}Lu	–	2E+3	9E-7	3E-9	–	–
71	Lutetium-178m[b/]	W, see ^{169}Lu	5E+4	2E+5	8E-5	3E-7	–	–
			St wall (6E+4)	–	–	–	8E-4	8E-3
		Y, see ^{169}Lu	–	2E+5	7E-5	2E-7	–	–
71	Lutetium-178[b/]	W, see ^{169}Lu	4E+4	1E+5	5E-5	2E-7	–	–
			St wall (4E+4)	–	–	–	6E-4	6E-3
		Y, see ^{169}Lu	–	1E+5	5E-5	2E-7	–	–
71	Lutetium-179	W, see ^{169}Lu	6E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		Y, see ^{169}Lu	–	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 ^{170}Hf	1E+3	9E+0	4E-9	–	2E-5	2E-4
			–	Bone surf (2E+1)	–	3E-11	–	–
		W, see ^{170}Hf	–	4E+1	2E-8	–	–	–
			–	Bone surf (6E+1)	–	8E-11	–	–
72	Hafnium-173	D, see ^{170}Hf	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see ^{170}Hf	–	1E+4	5E-6	2E-8	–	–
72	Hafnium-175	D, see ^{170}Hf	3E+3	9E+2	4E-7	–	4E-5	4E-4
			–	Bone surf (1E+3)	–	1E-9	–	–
		W, see ^{170}Hf	–	1E+3	5E-7	2E-9	–	–
72	Hafnium-177m[b/]	D, see ^{170}Hf	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
		W, see ^{170}Hf	–	9E+4	4E-5	1E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
72	Hafnium-178m	D, see ^{170}Hf	3E+2	1E+0	5E-10	–	3E-6	3E-5
			–	Bone surf (2E+0)	–	3E-12	–	–
		W, see ^{170}Hf	–	5E+0	2E-9	–	–	–
			–	Bone surf (9E+0)	–	1E-11	–	–
72	Hafnium-179m	D, see ^{170}Hf	1E+3	3E+2	1E-7	–	1E-5	1E-4
			–	Bone surf (6E+2)	–	8E-10	–	–
		W, see ^{170}Hf	–	6E+2	3E-7	8E-10	–	–
72	Hafnium-180m	D, see ^{170}Hf	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{170}Hf	–	3E+4	1E-5	4E-8	–	–
72	Hafnium-181	D, see ^{170}Hf	1E+3	2E+2	7E-8	–	2E-5	2E-4
			–	Bone surf (4E+2)	–	6E-10	–	–
		W, see ^{170}Hf	–	4E+2	2E-7	6E-10	–	–
72	Hafnium-182m[b/]	D, see ^{170}Hf	4E+4	9E+4	4E-5	1E-7	5E-4	5E-3
		W, see ^{170}Hf	–	1E+5	6E-5	2E-7	–	–
72	Hafnium-182	D, see ^{170}Hf	2E+2 Bone surf (4E+2)	8E-1 Bone surf (2E+0)	3E-10 –	– 2E-12	– 5E-6	– 5E-5
		W, see ^{170}Hf	–	3E+0	1E-9	–	–	–
			–	Bone surf (7E+0)	–	1E-11	–	–
72	Hafnium-183[b/]	D, see ^{170}Hf	2E+4	5E+4	2E-5	6E-8	3E-4	3E-3
		W, see ^{170}Hf	–	6E+4	2E-5	8E-8	–	–
72	Hafnium-184	D, see ^{170}Hf	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		W, see ^{170}Hf	–	6E+3	3E-6	9E-9	–	–
73	Tantalum-172[b/]	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 ^{172}Ta	7E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		Y, see ^{172}Ta	–	2E+4	7E-6	2E-8	–	–
73	Tantalum-174[b/]	W, see ^{172}Ta	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
		Y, see ^{172}Ta	–	9E+4	4E-5	1E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
73	Tantalum-175	W, see ^{172}Ta	6E+3	2E+4	7E-6	2E-8	8E-5	8E-4
		Y, see ^{172}Ta	–	1E+4	6E-6	2E-8	–	–
73	Tantalum-176	W, see ^{172}Ta	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
		Y, see ^{172}Ta	–	1E+4	5E-6	2E-8	–	–
73	Tantalum-177	W, see ^{172}Ta	1E+4	2E+4	8E-6	3E-8	2E-4	2E-3
		Y, see ^{172}Ta	–	2E+4	7E-6	2E-8	–	–
73	Tantalum-178	W, see ^{172}Ta	2E+4	9E+4	4E-5	1E-7	2E-4	2E-3
		Y, see ^{172}Ta	–	7E+4	3E-5	1E-7	–	–
73	Tantalum-179	W, see ^{172}Ta	2E+4	5E+3	2E-6	8E-9	3E-4	3E-3
		Y, see ^{172}Ta	–	9E+2	4E-7	1E-9	–	–
73	Tantalum-180m	W, see ^{172}Ta	2E+4	7E+4	3E-5	9E-8	3E-4	3E-3
		Y, see ^{172}Ta	–	6E+4	2E-5	8E-8	–	–
73	Tantalum-180	W, see ^{172}Ta	1E+3	4E+2	2E-7	6E-10	2E-5	2E-4
		Y, see ^{172}Ta	–	2E+1	1E-8	3E-11	–	–
73	Tantalum-182m[b/]	W, see ^{172}Ta	2E+5	5E+5	2E-4	8E-7	–	–
			St wall (2E+5)	–	–	–	3E-3	3E-2
		Y, see ^{172}Ta	–	4E+5	2E-4	6E-7	–	–
73	Tantalum-182	W, see ^{172}Ta	8E+2	3E+2	1E-7	5E-10	1E-5	1E-4
		Y, see ^{172}Ta	–	1E+2	6E-8	2E-10	–	–
73	Tantalum-183	W, see ^{172}Ta	9E+2	1E+3	5E-7	2E-9	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{172}Ta	–	1E+3	4E-7	1E-9	–	–
73	Tantalum-184	W, see ^{172}Ta	2E+3	5E+3	2E-6	8E-9	3E-5	3E-4
		Y, see ^{172}Ta	–	5E+3	2E-6	7E-9	–	–
73	Tantalum-185[b/]	W, see ^{172}Ta	3E+4	7E+4	3E-5	1E-7	4E-4	4E-3
		Y, see ^{172}Ta	–	6E+4	3E-5	9E-8	–	–
73	Tantalum-186[b/]	W, see ^{172}Ta	5E+4	2E+5	1E-4	3E-7	–	–
			St wall (7E+4)	–	–	–	1E-3	1E-2
		Y, see ^{172}Ta	–	2E+5	9E-5	3E-7	–	–
74	Tungsten-176	D, all compounds	1E+4	5E+4	2E-5	7E-8	1E-4	1E-3
74	Tungsten-177	D, all compounds	2E+4	9E+4	4E-5	1E-7	3E-4	3E-3
74	Tungsten-178	D, all compounds	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
74	Tungsten-179[b/]	D, all compounds	5E+5	2E+6	7E-4	2E-6	7E-3	7E-2
74	Tungsten-181	D, all compounds	2E+4	3E+4	1E-5	5E-8	2E-4	2E-3
74	Tungsten-185	D, all compounds	2E+3	7E+3	3E-6	9E-9	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
74	Tungsten-187	D, all compounds	2E+3	9E+3	4E-6	1E-8	3E-5	3E-4
74	Tungsten-188	D, all compounds	4E+2	1E+3	5E-7	2E-9	–	–
			LLI wall (5E+2)	–	–	–	7E-6	7E-5
75	Rhenium-177[b/]	D, all compounds except those given for W	9E+4	3E+5	1E-4	4E-7	–	–
			St wall (1E+5)	–	–	–	2E-3	2E-2
		W, oxides, hydroxides, and nitrates	–	4E+5	1E-4	5E-7	–	–
75	Rhenium-178[b/]	D, see ^{177}Re	7E+4	3E+5	1E-4	4E-7	–	–
			St wall (1E+5)	–	–	–	1E-3	1E-2
		W, see ^{177}Re	–	3E+5	1E-4	4E-7	–	–
75	Rhenium-181	D, see ^{177}Re	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
		W, see ^{177}Re	–	9E+3	4E-6	1E-8	–	–
75	Rhenium-182 (12.7 h)	D, see ^{177}Re	7E+3	1E+4	5E-6	2E-8	9E-5	9E-4
		W, see ^{177}Re	–	2E+4	6E-6	2E-8	–	–
75	Rhenium-182 (64.0 h)	D, see ^{177}Re	1E+3	2E+3	1E-6	3E-9	2E-5	2E-4
		W, see ^{177}Re	–	2E+3	9E-7	3E-9	–	–
75	Rhenium-184m	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
		W, see ^{177}Re	–	4E+2	2E-7	6E-10	–	–
75	Rhenium-184	D, see ^{177}Re	2E+3	4E+3	1E-6	5E-9	3E-5	3E-4
		W, see ^{177}Re	–	1E+3	6E-7	2E-9	–	–
75	Rhenium-186m	D, see ^{177}Re	1E+3	2E+3	7E-7	–	–	–
			St wall (2E+3)	St wall (2E+3)	–	3E-9	2E-5	2E-4
		W, see ^{177}Re	–	2E+2	6E-8	2E-10	–	–
75	Rhenium-186	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
		W, see ^{177}Re	–	2E+3	7E-7	2E-9	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
75	Rhenium-187	D, see ^{177}Re	6E+5	8E+5	4E-4	–	8E-3	8E-2
			–	St wall (9E+5)	–	1E-6	–	–
		W, see ^{177}Re	–	1E+5	4E-5	1E-7	–	–
75	Rhenium-188m[b/]	D, see ^{177}Re	8E+4	1E+5	6E-5	2E-7	1E-3	1E-2
		W, see ^{177}Re	–	1E+5	6E-5	2E-7	–	–
75	Rhenium-188	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		W, see ^{177}Re	–	3E+3	1E-6	4E-9	–	–
75	Rhenium-189	D, see ^{177}Re	3E+3	5E+3	2E-6	7E-9	4E-5	4E-4
		W, see ^{177}Re	–	4E+3	2E-6	6E-9	–	–
76	Osmium-180[b/]	D, all compounds except those given for W and Y	1E+5	4E+5	2E-4	5E-7	1E-3	1E-2
		W, halides and nitrates	–	5E+5	2E-4	7E-7	–	–
		Y, oxides and hydroxides	–	5E+5	2E-4	6E-7	–	–
76	Osmium-181[b/]	D, see ^{180}Os	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{180}Os	–	5E+4	2E-5	6E-8	–	–
		Y, see ^{180}Os	–	4E+4	2E-5	6E-8	–	–
76	Osmium-182	D, see ^{180}Os	2E+3	6E+3	2E-6	8E-9	3E-5	3E-4
		W, see ^{180}Os	–	4E+3	2E-6	6E-9	–	–
		Y, see ^{180}Os	–	4E+3	2E-6	6E-9	–	–
76	Osmium-185	D, see ^{180}Os	2E+3	5E+2	2E-7	7E-10	3E-5	3E-4
		W, see ^{180}Os	–	8E+2	3E-7	1E-9	–	–
		Y, see ^{180}Os	–	8E+2	3E-7	1E-9	–	–
76	Osmium-189m	D, see ^{180}Os	8E+4	2E+5	1E-4	3E-7	1E-3	1E-2
		W, see ^{180}Os	–	2E+5	9E-5	3E-7	–	–
		Y, see ^{180}Os	–	2E+5	7E-5	2E-7	–	–
76	Osmium-191m	D, see ^{180}Os	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{180}Os	–	2E+4	8E-6	3E-8	–	–
		Y, see ^{180}Os	–	2E+4	7E-6	2E-8	–	–
76	Osmium-191	D, see ^{180}Os	2E+3	2E+3	9E-7	3E-9	–	–
			LLI wall (3E+3)	–	–	–	3E-5	3E-4
		W, see ^{180}Os	–	2E+3	7E-7	2E-9	–	–
		Y, see ^{180}Os	–	1E+3	6E-7	2E-9	–	–
76	Osmium-193	D, see ^{180}Os	2E+3	5E+3	2E-6	6E-9	–	–
			LLI wall (2E+3)	–	–	–	2E-5	2E-4
		W, see ^{180}Os	–	3E+3	1E-6	4E-9	–	–
		Y, see ^{180}Os	–	3E+3	1E-6	4E-9	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values: Col. 1 Oral Ingestion ALI (µCi)	Table I Occupational Values: Inhalation Col. 2 ALI (µCi)	Table I Occupational Values: Inhalation Col. 3 DAC (µCi/ml)	Table II Effluent Concentrations: Col. 1 Air (µCi/ml)	Table II Effluent Concentrations: Col. 2 Water (µCi/ml)	Table III Releases to Sewers: Monthly Average Concentration (µCi/ml)
76	Osmium-194	D, see ^{180}Os	4E+2	4E+1	2E-8	6E-11	–	–
			LLI wall (6E+2)	–	–	–	8E-6	8E-5
		W, see ^{180}Os	–	6E+1	2E-8	8E-11	–	–
		Y, see ^{180}Os	–	8E+0	3E-9	1E-11	–	–
77	Iridium-182[b/]	D, all compounds except those given for W and Y	4E+4	1E+5	6E-5	2E-7	–	–
			St wall (4E+4)	–	–	–	6E-4	6E-3
		W, halides, nitrates, and metallic iridium	–	2E+5	6E-5	2E-7	–	–
		Y, oxides and hydroxides	–	1E+5	5E-5	2E-7	–	–
77	Iridium-184	D, see ^{182}Ir	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{182}Ir	–	3E+4	1E-5	5E-8	–	–
		Y, see ^{182}Ir	–	3E+4	1E-5	4E-8	–	–
77	Iridium-185	D, see ^{182}Ir	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see ^{182}Ir	–	1E+4	5E-6	2E-8	–	–
		Y, see ^{182}Ir	–	1E+4	4E-6	1E-8	–	–
77	Iridium-186	D, see ^{182}Ir	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		W, see ^{182}Ir	–	6E+3	3E-6	9E-9	–	–
		Y, see ^{182}Ir	–	6E+3	2E-6	8E-9	–	–
77	Iridium-187	D, see ^{182}Ir	1E+4	3E+4	1E-5	5E-8	1E-4	1E-3
		W, see ^{182}Ir	–	3E+4	1E-5	4E-8	–	–
		Y, see ^{182}Ir	–	3E+4	1E-5	4E-8	–	–
77	Iridium-188	D, see ^{182}Ir	2E+3	5E+3	2E-6	6E-9	3E-5	3E-4
		W, see ^{182}Ir	–	4E+3	1E-6	5E-9	–	–
		Y, see ^{182}Ir	–	3E+3	1E-6	5E-9	–	–
77	Iridium-189	D, see ^{182}Ir	5E+3	5E+3	2E-6	7E-9	–	–
			LLI wall (5E+3)	–	–	–	7E-5	7E-4
		W, see ^{182}Ir	–	4E+3	2E-6	5E-9	–	–
		Y, see ^{182}Ir	–	4E+3	1E-6	5E-9	–	–
77	Iridium-190m[b/]	D, see ^{182}Ir	2E+5	2E+5	8E-5	3E-7	2E-3	2E-2
		W, see ^{182}Ir	–	2E+5	9E-5	3E-7	–	–
		Y, see ^{182}Ir	–	2E+5	8E-5	3E-7	–	–
77	Iridium-190	D, see ^{182}Ir	1E+3	9E+2	4E-7	1E-9	1E-5	1E-4
		W, see ^{182}Ir	–	1E+3	4E-7	1E-9	–	–
		Y, see ^{182}Ir	–	9E+2	4E-7	1E-9	–	–
77	Iridium-192m	D, see ^{182}Ir	3E+3	9E+1	4E-8	1E-10	4E-5	4E-4
		W, see ^{182}Ir	–	2E+2	9E-8	3E-10	–	–
		Y, see ^{182}Ir	–	2E+1	6E-9	2E-11	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
77	Iridium-192	D, see ^{182}Ir	9E+2	3E+2	1E-7	4E-10	1E-5	1E-4
		W, see ^{182}Ir	–	4E+2	2E-7	6E-10	–	–
		Y, see ^{182}Ir	–	2E+2	9E-8	3E-10	–	–
77	Iridium-194m	D, see ^{182}Ir	6E+2	9E+1	4E-8	1E-10	9E-6	9E-5
		W, see ^{182}Ir	–	2E+2	7E-8	2E-10	–	–
		Y, see ^{182}Ir	–	1E+2	4E-8	1E-10	–	–
77	Iridium-194	D, see ^{182}Ir	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
		W, see ^{182}Ir	–	2E+3	9E-7	3E-9	–	–
		Y, see ^{182}Ir	–	2E+3	8E-7	3E-9	–	–
77	Iridium-195m	D, see ^{182}Ir	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{182}Ir	–	3E+4	1E-5	4E-8	–	–
		Y, see ^{182}Ir	–	2E+4	9E-6	3E-8	–	–
77	Iridium-195	D, see ^{182}Ir	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{182}Ir	–	5E+4	2E-5	7E-8	–	–
		Y, see ^{182}Ir	–	4E+4	2E-5	6E-8	–	–
78	Platinum-186	D, all compounds	1E+4	4E+4	2E-5	5E-8	2E-4	2E-3
78	Platinum-188	D, all compounds	2E+3	2E+3	7E-7	2E-9	2E-5	2E-4
78	Platinum-189	D, all compounds	1E+4	3E+4	1E-5	4E-8	1E-4	1E-3
78	Platinum-191	D, all compounds	4E+3	8E+3	4E-6	1E-8	5E-5	5E-4
78	Platinum-193m	D, all compounds	3E+3	6E+3	3E-6	8E-9	–	–
			LLI wall (3E+4)	–	–	–	4E-5	4E-4
78	Platinum-193	D, all compounds	4E+4	2E+4	1E-5	3E-8	–	–
			LLI wall (5E+4)	–	–	–	6E-4	6E-3
78	Platinum-195m	D, all compounds	2E+3	4E+3	2E-6	6E-9	–	–
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
78	Platinum-197m[b/]	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[b/]	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

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

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

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
80	Mercury-193	Vapor	–	3E+4	1E-5	4E-8	–	–
		Organic D	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		D, see ^{193m}Hg	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{193m}Hg	–	4E+4	2E-5	6E-8	–	–
80	Mercury-194	Vapor	–	3E+1	1E-8	4E-11	–	–
		Organic D	2E+1	3E+1	1E-8	4E-11	2E-7	2E-6
		D, see ^{193m}Hg	8E+2	4E+1	2E-8	6E-11	1E-5	1E-4
		W, see ^{193m}Hg	–	1E+2	5E-8	2E-10	–	–
80	Mercury-195m	Vapor	–	4E+3	2E-6	6E-9	–	–
		Organic D	3E+3	6E+3	3E-6	8E-9	4E-5	4E-4
		D, see ^{193m}Hg	2E+3	5E+3	2E-6	7E-9	3E-5	3E-4
		W, see ^{193m}Hg	–	4E+3	2E-6	5E-9	–	–
80	Mercury-195	Vapor	–	3E+4	1E-5	4E-8	–	–
		Organic D	2E+4	5E+4	2E-5	6E-8	2E-4	2E-3
		D, see ^{193m}Hg	1E+4	4E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{193m}Hg	–	3E+4	1E-5	5E-8	–	–
80	Mercury-197m	Vapor	–	5E+3	2E-6	7E-9	–	–
		Organic D	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
		D, see ^{193m}Hg	3E+3	7E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{193m}Hg	–	5E+3	2E-6	7E-9	–	–
80	Mercury-197	Vapor	–	8E+3	4E-6	1E-8	–	–
		Organic D	7E+3	1E+4	6E-6	2E-8	9E-5	9E-4
		D, see ^{193m}Hg	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, see ^{193m}Hg	–	9E+3	4E-6	1E-8	–	–
80	Mercury-199m[b/]	Vapor	–	8E+4	3E-5	1E-7	–	–
		Organic D	6E+4	2E+5	7E-5	2E-7	–	–
			St wall (1E+5)	–	–	–	1E-3	1E-2
		D, see ^{193m}Hg	6E+4	1E+5	6E-5	2E-7	8E-4	8E-3
		W, see ^{193m}Hg	–	2E+5	7E-5	2E-7	–	–
80	Mercury-203	Vapor	–	8E+2	4E-7	1E-9	–	–
		Organic D	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
		D, see ^{193m}Hg	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
		W, see ^{193m}Hg	–	1E+3	5E-7	2E-9	–	–
81	Thallium-194m[b/]	D, all compounds	5E+4	2E+5	6E-5	2E-7	–	–
			St wall (7E+4)	–	–	–	1E-3	1E-2
81	Thallium-194[b/]	D, all compounds	3E+5	6E+5	2E-4	8E-7	–	–
			St wall (3E+5)	–	–	–	4E-3	4E-2
81	Thallium-195[b/]	D, all compounds	6E+4	1E+5	5E-5	2E-7	9E-4	9E-3

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
81	Thallium-197	D, all compounds	7E+4	1E+5	5E-5	2E-7	1E-3	1E-2
81	Thallium-198m[b/]	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[b/]	D, all compounds	6E+4	2E+5	8E-5	3E-7	8E-4	8E-3
82	Lead-198	D, all compounds	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
82	Lead-199[b/]	D, all compounds	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
82	Lead-200	D, all compounds	3E+3	6E+3	3E-6	9E-9	4E-5	4E-4
82	Lead-201	D, all compounds	7E+3	2E+4	8E-6	3E-8	1E-4	1E-3
82	Lead-202m	D, all compounds	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
82	Lead-202	D, all compounds	1E+2	5E+1	2E-8	7E-11	2E-6	2E-5
82	Lead-203	D, all compounds	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
82	Lead-205	D, all compounds	4E+3	1E+3	6E-7	2E-9	5E-5	5E-4
82	Lead-209	D, all compounds	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
82	Lead-210	D, all compounds	6E-1 Bone surf (1E+0)	2E-1 Bone surf (4E-1)	1E-10 –	– 6E-13	– 1E-8	– 1E-7
82	Lead-211[b/]	D, all compounds	1E+4	6E+2	3E-7	9E-10	2E-4	2E-3
82	Lead-212	D, all compounds	8E+1 Bone surf (1E+2)	3E+1 –	1E-8 –	5E-11 –	– 2E-6	– 2E-5
82	Lead-214[b/]	D, all compounds	9E+3	8E+2	3E-7	1E-9	1E-4	1E-3
83	Bismuth-200[b/]	D, nitrates W, all other compounds	3E+4 –	8E+4 1E+5	4E-5 4E-5	1E-7 1E-7	4E-4 –	4E-3 –

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
83	Bismuth-201[b/]	D, see ^{200}Bi	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{200}Bi	–	4E+4	2E-5	5E-8	–	–
83	Bismuth-202[b/]	D, see ^{200}Bi	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{200}Bi	–	8E+4	3E-5	1E-7	–	–
83	Bismuth-203	D, see ^{200}Bi	2E+3	7E+3	3E-6	9E-9	3E-5	3E-4
		W, see ^{200}Bi	–	6E+3	3E-6	9E-9	–	–
83	Bismuth-205	D, see ^{200}Bi	1E+3	3E+3	1E-6	3E-9	2E-5	2E-4
		W, see ^{200}Bi	–	1E+3	5E-7	2E-9	–	–
83	Bismuth-206	D, see ^{200}Bi	6E+2	1E+3	6E-7	2E-9	9E-6	9E-5
		W, see ^{200}Bi	–	9E+2	4E-7	1E-9	–	–
83	Bismuth-207	D, see ^{200}Bi	1E+3	2E+3	7E-7	2E-9	1E-5	1E-4
		W, see ^{200}Bi	–	4E+2	1E-7	5E-10	–	–
83	Bismuth-210m	D, see ^{200}Bi	4E+1 Kidneys (6E+1)	5E+0 Kidneys (6E+0)	2E-9 –	– 9E-12	– 8E-7	– 8E-6
		W, see ^{200}Bi	–	7E-1	3E-10	9E-13	–	–
83	Bismuth-210	D, see ^{200}Bi	8E+2 – –	2E+2 Kidneys (4E+2)	1E-7 –	– 5E-10	1E-5 –	1E-4 –
		W, see ^{200}Bi	–	3E+1	1E-8	4E-11	–	–
83	Bismuth-212[b/]	D, see ^{200}Bi	5E+3	2E+2	1E-7	3E-10	7E-5	7E-4
		W, see ^{200}Bi	–	3E+2	1E-7	4E-10	–	–
83	Bismuth-213[b/]	D, see ^{200}Bi	7E+3	3E+2	1E-7	4E-10	1E-4	1E-3
		W, see ^{200}Bi	–	4E+2	1E-7	5E-10	–	–
83	Bismuth-214[b/]	D, see ^{200}Bi	2E+4 St wall (2E+4)	8E+2 –	3E-7 –	1E-9 –	– 3E-4	– 3E-3
		W, see ^{200}Bi	–	9E-2	4E-7	1E-9	–	–
84	Polonium-203[b/]	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[b/]	D, see ^{203}Po	2E+4	4E+4	2E-5	5E-8	3E-4	3E-3
		W, see ^{203}Po	–	7E+4	3E-5	1E-7	–	–
84	Polonium-207	D, see ^{203}Po	8E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{203}Po	–	3E+4	1E-5	4E-8	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
84	Polonium-210	D, see ^{203}Po	3E+0	6E-1	3E-10	9E-13	4E-8	4E-7
		W, see ^{203}Po	–	6E-1	3E-10	9E-13	–	–
85	Astatine-207[b/]	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 (or 12 WLM)	9E-9 (or 1.0 WL)	3E-11	–	–
86	Radon-222	With daughters removed	–	1E+4	4E-6	1E-8	–	–
		With daughters present	–	1E+2 (or 4 WLM)	3E-8 (or 0.33 WL)	1E-10	–	–
87	Francium-222[b/]	D, all compounds	2E+3	5E+2	2E-7	6E-10	3E-5	3E-4
87	Francium-223[b/]	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
88	Radium-226	W, all compounds	2E+0	6E-1	3E-10	9E-13	–	–
			Bone surf (5E+0)	–	–	–	6E-8	6E-7
88	Radium-227[b/]	W, all compounds	2E+4	1E+4	6E-6	–	–	–
			Bone surf (2E+4)	Bone surf (2E+4)	–	3E-8	3E-4	3E-3
88	Radium-228	W, all compounds	2E+0	1E+0	5E-10	2E-12	–	–
			Bone surf (4E+0)	–	–	–	6E-8	6E-7

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values: Col. 1 Oral Ingestion ALI (µCi)	Table I Occupational Values: Inhalation Col. 2 ALI (µCi)	Table I Occupational Values: Inhalation Col. 3 DAC (µCi/ml)	Table II Effluent Concentrations: Col. 1 Air (µCi/ml)	Table II Effluent Concentrations: Col. 2 Water (µCi/ml)	Table III Releases to Sewers: Monthly Average Concentration (µCi/ml)
89	Actinium-224	D, all compounds except those given for W and Y	2E+3	3E+1	1E-8	–	–	–
			LLI wall (2E+3)	Bone surf (4E+1)	–	5E-11	3E-5	3E-4
		W, halides and nitrates	–	5E+1	2E-8	7E-11	–	–
		Y, oxides and hydroxides	–	5E+1	2E-8	6E-11	–	–
89	Actinium-225	D, see ^{224}Ac	5E+1	3E-1	1E-10	–	–	–
			LLI wall (5E+1)	Bone surf (5E-1)	-	7E-13	7E-7	7E-6
		W, see ^{224}Ac	–	6E-1	3E-10	9E-13	–	–
		Y, see ^{224}Ac	–	6E-1	3E-10	9E-13	–	–
89	Actinium-226	D, see ^{224}Ac	1E+2	3E+0	1E-9	–	–	–
			LLI wall (1E+2)	Bone surf (4E+0)	–	5E-12	2E-6	2E-5
		W, see ^{224}Ac	–	5E+0	2E-9	7E-12	–	–
		Y, see ^{224}Ac	–	5E+0	2E-9	6E-12	–	–
89	Actinium-227	D, see ^{224}Ac	2E-1	4E-4	2E-13	–	–	–
			Bone surf (4E-1)	Bone surf (8E-4)	–	1E-15	5E-9	5E-8
		W, see ^{224}Ac	–	2E-3	7E-13	–	–	–
			–	Bone surf (3E-3)	–	4E-15	–	–
		Y, see ^{224}Ac	–	4E-3	2E-12	6E-15	–	–
89	Actinium-228	D, see ^{224}Ac	2E+3	9E+0	4E-9	–	3E-5	3E-4
			–	Bone surf (2E+1)	–	2E-11	–	–
		W, see ^{224}Ac	–	4E+1	2E-8	–	–	–
			–	Bone surf (6E+1)	–	8E-11	–	–
		Y, see ^{224}Ac	–	4E+1	2E-8	6E-11	–	–
90	Thorium-226[b/]	W, all compounds except those given for Y	5E+3	2E+2	6E-8	2E-10	–	–
			St wall (5E+3)	–	–	–	7E-5	7E-4
		Y, oxides and hydroxides	–	1E+2	6E-8	2E-10	–	–
90	Thorium-227	W, see ^{226}Th	1E+2	3E-1	1E-10	5E-13	2E-6	2E-5
		Y, see ^{226}Th	–	3E-1	1E-10	5E-13	–	–
90	Thorium-228	W, see ^{226}Th	6E+0	1E-2	4E-12	–	–	–
			Bone surf (1E+1)	Bone surf (2E-2)	–	3E-14	2E-7	2E-6
		Y, see ^{226}Th	–	2E-2	7E-12	2E-14	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
90	Thorium-229	W, see ^{226}Th	6E-1	9E-4	4E-13	–	–	–
			Bone surf (1E+0)	Bone surf (2E-3)	–	3E-15	2E-8	2E-7
		Y, see ^{226}Th	–	2E-3	1E-12	–	–	–
			–	Bone surf (3E-3)	–	4E-15	–	–
90	Thorium-230	W, see ^{226}Th	4E+0	6E-3	3E-12	–	–	–
			Bone surf (9E+0)	Bone surf (2E-2)	–	2E-14	1E-7	1E-6
		Y, see ^{226}Th	–	2E-2	6E-12	–	–	–
			–	Bone surf (2E-2)	–	3E-14	–	–
90	Thorium-231	W, see ^{226}Th	4E+3	6E+3	3E-6	9E-9	5E-5	5E-4
		Y, see ^{226}Th	–	6E+3	3E-6	9E-9	–	–
90	Thorium-232	W, see ^{226}Th	7E-1	1E-3	5E-13	–	–	–
			Bone surf (2E+0)	Bone surf (3E-3)	–	4E-15	3E-8	3E-7
		Y, see ^{226}Th	–	3E-3	1E-12	–	–	–
			–	Bone sur (4E-3)	–	6E-15	–	–
90	Thorium-234	W, see ^{226}Th	3E+2	2E+2	8E-8	3E-10	–	–
			LLI wall (4E+2)	–	–	–	5E-6	5E-5
		Y, see ^{226}Th	–	2E+2	6E-8	2E-10	–	–
91	Protactinium-227[b/]	W, all compounds except those given for Y	4E+3	1E+2	5E-8	2E-10	5E-5	5E-4
		Y, oxides and hydroxides	–	1E+2	4E-8	1E-10	–	–
91	Protactinium-228	W, see ^{227}Pa	1E+3	1E+1	5E-9	–	2E-5	2E-4
			–	Bone surf (2E+1)	–	3E-11	–	–
		Y, see ^{227}Pa	–	1E+1	5E-9	2E-11	–	–
91	Protactinium-230	W, see ^{227}Pa	6E+2	5E+0	2E-9	7E-12	–	–
			Bone surf (9E+2)	–	–	–	1E-5	1E-4
		Y, see ^{227}Pa	–	4E+0	1E-9	5E-12	–	–
91	Protactinium-231	W, see ^{227}Pa	2E-1	2E-3	6E-13	–	–	–
			Bone surf (5E-1)	Bone surf (4E-3)	–	6E-15	6E-9	6E-8
		Y, see ^{227}Pa	–	4E-3	2E-12	–	–	–
			–	Bone surf (6E-3)	–	8E-15	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
91	Protactinium-232	W, see ^{227}Pa	1E+3	2E+1	9E-9	–	2E-5	2E-4
			–	Bone surf (6E+1)	–	8E-11	–	–
		Y, see ^{227}Pa	–	6E+1	2E-8	–	–	–
			–	Bone surf (7E+1)	–	1E-10	–	–
91	Protactinium-233	W, see ^{227}Pa	1E+3	7E+2	3E-7	1E-9	–	–
			LLI wall (2E+3)	–	–	–	2E-5	2E-4
		Y, see ^{227}Pa	–	6E+2	2E-7	8E-10	–	–
91	Protactinium-234	W, see ^{227}Pa	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		Y, see ^{227}Pa	–	7E+3	3E-6	9E-9	–	–
92	Uranium-230	D, UF_6, UO_2F_2, UO_2,$(NO_3)_2$	4E+0 Bone surf (6E+0)	4E-1 Bone surf (6E-1)	2E-10 –	– 8E-13	– 8E-8	– 8E-7
		W, UO_3, UF_4, UCl_4	–	4E-1	1E-10	5E-13	–	–
		Y, UO_2, U_3O_8	–	3E-1	1E-10	4E-13	–	–
92	Uranium-231	D, see ^{230}U	5E+3	8E+3	3E-6	1E-8	–	–
			LLI wall (4E+3)	–	–	–	6E-5	6E-4
		W, see ^{230}U	–	6E+3	2E-6	8E-9	–	–
		Y, see ^{230}U	–	5E+3	2E-6	6E-9	–	–
92	Uranium-232	D, see ^{230}U	2E+0 Bone surf (4E+0)	2E-1 Bone surf (4E-1)	9E-11 –	– 6E-13	– 6E-8	– 6E-7
		W, see ^{230}U	–	4E-1	2E-10	5E-13	–	–
		Y, see ^{230}U	–	8E-3	3E-12	1E-14	–	–
92	Uranium-233	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10 –	– 3E-12	– 3E-7	– 3E-6
		W, see ^{230}U	–	7E-1	3E-10	1E-12	–	–
		Y, see ^{230}U	–	4E-2	2E-11	5E-14	–	–
92	Uranium-234[g/]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10 –	– 3E-12	– 3E-7	– 3E-6
		W, see ^{230}U	–	7E-1	3E-10	1E-12	–	–
		Y, see ^{230}U	–	4E-2	2E-11	5E-14	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
92	Uranium-235[c/]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	6E-10 –	– 3E-12	– 3E-7	– 3E-6
		W, see ^{230}U	–	8E-1	3E-10	1E-12	–	–
		Y, see ^{230}U	–	4E-2	2E-11	6E-14	–	–
92	Uranium-236	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10 –	– 3E-12	– 3E-7	– 3E-6
		W, see ^{230}U	–	8E-1	3E-10	1E-12	–	–
		Y, see ^{230}U	–	4E-2	2E-11	6E-14	–	–
92	Uranium-237	D, see ^{230}U	2E+3 LLI wall (2E+3)	3E+3 –	1E-6 –	4E-9 -	– 3E-5	– 3E-4
		W, see ^{230}U	–	2E+3	7E-7	2E-9	–	–
		Y, see ^{230}U	–	2E+3	6E-7	2E-9	–	–
92	Uranium-238[c/]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	6E-10 –	– 3E-12	– 3E-7	– 3E-6
		W, see ^{230}U	–	8E-1	3E-10	1E-12	–	–
		Y, see ^{230}U	–	4E-2	2E-11	6E-14	–	–
92	Uranium-239[b/]	D, see ^{230}U	7E+4	2E+5	8E-5	3E-7	9E-4	9E-3
		W, see ^{230}U	–	2E+5	7E-5	2E-7	–	–
		Y, see ^{230}U	–	2E+5	6E-5	2E-7	–	–
92	Uranium-240	D, see ^{230}U	1E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		W, see ^{230}U	–	3E+3	1E-6	4E-9	–	–
		Y, see ^{230}U	–	2E+3	1E-6	3E-9	–	–
92	Uranium-natural[c/]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10 –	– 3E-12	– 3E-7	– 3E-6
		W, see ^{230}U	–	8E-1	3E-10	9E-13	–	–
		Y, see ^{230}U	–	5E-2	2E-11	9E-14	–	–
93	Neptunium-232[b/]	W, all compounds	1E+5 –	2E+3 Bone surf (5E+2)	7E-7 –	– 6E-9	2E-3 –	2E-2 –
93	Neptunium-233[b/]	W, all compounds	8E+5	3E+6	1E-3	4E-6	1E-2	1E-1
93	Neptunium-234	W, all compounds	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
93	Neptunium-235	W, all compounds	2E+4 LLI wall (2E+4)	8E+2 Bone surf (1E+3)	3E-7 –	– 2E-9	– 3E-4	– 3E-3

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
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[b/]	W, all compounds	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
94	Plutonium-234	W, all compounds except PuO_2	8E+3	2E+2	9E-8	3E-10	1E-4	1E-3
		Y, PuO_2	–	2E+2	8E-8	3E-10	–	–
94	Plutonium-235[b/]	W, see ^{234}Pu	9E+5	3E+6	1E-3	4E-6	1E-2	1E-1
		Y, see ^{234}Pu	–	3E+6	1E-3	3E-6	–	–
94	Plutonium-236	W, see ^{234}Pu	2E+0	2E-2	8E-12	–	–	–
			Bone surf (4E+0)	Bone surf (4E-2)	–	5E-14	6E-8	6E-7
		Y, see ^{234}Pu	–	4E-2	2E-11	6E-14	–	–
94	Plutonium-237	W, see ^{234}Pu	1E+4	3E+3	1E-6	5E-9	2E-4	2E-3
		Y, see ^{234}Pu	–	3E+3	1E-6	4E-9	–	–
94	Plutonium-238	W, see ^{234}Pu	9E-1	7E-3	3E-12	–	–	–
			Bone surf (2E+0)	Bone surf (1E-2)	–	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	–	2E-2	8E-12	2E-14	–	–
94	Plutonium-239	W, see ^{234}Pu	8E-1	6E-3	3E-12	–	–	–
			Bone surf (1E+0)	Bone surf (1E-2)	–	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	–	2E-2	7E-12	–	–	–
			–	Bone surf (2E-2)	–	2E-14	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
94	Plutonium-240	W, see ^{234}Pu	8E-1	6E-3	3E-12	–	–	–
			Bone surf (1E+0)	Bone surf (1E-2)	–	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	–	2E-2	7E-12	–	–	–
			–	Bone surf (2E-2)	–	2E-14	–	–
94	Plutonium-241	W, see ^{234}Pu	4E+1	3E-1	1E-10	–	–	–
			Bone surf (7E+1)	Bone surf (6E-1)	–	8E-13	1E-6	1E-5
		Y, see ^{234}Pu	–	8E-1	3E-10	–	–	–
			–	Bone surf (1E+0)	–	1E-12	–	–
94	Plutonium-242	W, see ^{234}Pu	8E-1	7E-3	3E-12	–	–	–
			Bone surf (1E+0)	Bone surf (1E-2)	–	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	–	2E-2	7E-12	–	–	–
			–	Bone surf (2E-2)	–	2E-14	–	–
94	Plutonium-243	W, see ^{234}Pu	2E+4	4E+4	2E-5	5E-8	2E-4	2E-3
		Y, see ^{234}Pu	–	4E+4	2E-5	5E-8	–	–
94	Plutonium-244	W, see ^{234}Pu	8E-1	7E-3	3E-12	–	–	–
			Bone surf (2E+0)	Bone surf (1E-2)	–	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	–	2E-2	7E-12	–	–	–
			–	Bone surf (2E-2)	–	2E-14	–	–
94	Plutonium-245	W, see ^{234}Pu	2E+3	5E+3	2E-6	6E-9	3E-5	3E-4
		Y, see ^{234}Pu	–	4E+3	2E-6	6E-9	–	–
94	Plutonium-246	W, see ^{234}Pu	4E+2	3E+2	1E-7	4E-10	–	–
			LLI wall (4E+2)	–	–	–	6E-6	6E-5
		Y, see ^{234}Pu	–	3E+2	1E-7	4E-10	–	–
95	Americium-237[b/]	W, all compounds	8E+4	3E+5	1E-4	4E-7	1E-3	1E-2
95	Americium-238[b/]	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

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
95	Americium-241	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
95	Americium-242m	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
95	Americium-242	W, all compounds	4E+3 –	8E+1 Bone surf (9E+1)	4E-8 –	– 1E-10	5E-5 –	5E-4 –
95	Americium-243	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
95	Americium-244m[b/]	W, all compounds	6E+4 St wall (8E+4)	4E+3 Bone surf (7E+3)	2E-6 –	– 1E-8	– 1E-3	– 1E-2
95	Americium-244	W, all compounds	3E+3 –	2E+2 Bone surf (3E+2)	8E-8 –	– 4E-10	4E-5 –	4E-4 –
95	Americium-245	W, all compounds	3E+4	8E+4	3E-5	1E-7	4E-4	4E-3
95	Americium-246m[b/]	W, all compounds	5E+4 St wall (6E+4)	2E+5 –	8E-5 –	3E-7 –	– 8E-4	– 8E-3
95	Americium-246[b/]	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 Bone surf (8E+1)	6E-1 Bone surf (6E-1)	2E-10 –	– 9E-13	– 1E-6	– 1E-5
96	Curium-241	W, all compounds	1E+3 –	3E+1 Bone surf (4E+1)	1E-8 –	– 5E-11	2E-5 –	2E-4 –
96	Curium-242	W, all compounds	3E+1 Bone surf (5E+1)	3E-1 Bone surf (3E-1)	1E-10 –	– 4E-13	– 7E-7	– 7E-6
96	Curium-243	W, all compounds	1E+0 Bone surf (2E+0)	9E-3 Bone surf (2E-2)	4E-12 –	– 2E-14	– 3E-8	– 3E-7

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
96	Curium-244	W, all compounds	1E+0 Bone surf (3E+0)	1E-2 Bone surf (2E-2)	5E-12 –	– 3E-14	– 3E-8	– 3E-7
96	Curium-245	W, all compounds	7E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
96	Curium-246	W, all compounds	7E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
96	Curium-247	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
96	Curium-248	W, all compounds	2E-1 Bone surf (4E-1)	2E-3 Bone surf (3E-3)	7E-13 –	– 4E-15	– 5E-9	– 5E-8
96	Curium-249[b/]	W, all compounds	5E+4 –	2E+4 Bone surf (3E+4)	7E-6 –	– 4E-8	7E-4 –	7E-3 –
96	Curium-250	W, all compounds	4E-2 Bone surf (6E-2)	3E-4 Bone surf (5E-4)	1E-13 –	– 8E-16	– 9E-10	– 9E-9
97	Berkelium-245	W, all compounds	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
97	Berkelium-246	W, all compounds	3E+3	3E+3	1E-6	4E-9	4E-5	4E-4
97	Berkelium-247	W, all compounds	5E-1 Bone surf (1E+0)	4E-3 Bone surf (9E-3)	2E-12 –	– 1E-14	– 2E-8	– 2E-7
97	Berkelium-249	W, all compounds	2E+2 Bone surf (5E+2)	2E+0 Bone surf (4E+0)	7E-10 –	– 5E-12	– 6E-6	– 6E-5
97	Berkelium-250	W, all compounds	9E+3 –	3E+2 Bone surf (7E+2)	1E-7 –	– 1E-9	1E-4 –	1E-3 –
98	Californium-244[b/]	W, all compounds except those given for Y	3E+4 St wall (3E+4)	6E+2 –	2E-7 –	8E-10 –	– 4E-4	– 4E-3
		Y, oxides and hydroxides	–	6E+2	2E-7	8E-10	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
98	Californium-246	W, see ^{244}Cf	4E+2	9E+0	4E-9	1E-11	5E-6	5E-5
		Y, see ^{244}Cf	–	9E+0	4E-9	1E-11	–	–
98	Californium-248	W, see ^{244}Cf	8E+0	6E-2	3E-11	–	–	–
			Bone surf (2E+1)	Bone surf (1E-1)	–	2E-13	2E-7	2E-6
		Y, see ^{244}Cf	–	1E-1	4E-11	1E-13	–	–
98	Californium-249	W, see ^{244}Cf	5E-1	4E-3	2E-12	–	–	–
			Bone surf (1E+0)	Bone surf (9E-3)	–	1E-14	2E-8	2E-7
		Y, see ^{244}Cf	–	1E-2	4E-12	–	–	–
				Bone surf				
			–	(1E-2)	–	2E-14	–	–
98	Californium-250	W, see ^{244}Cf	1E+0	9E-3	4E-12	–	–	–
			Bone surf (2E+0)	Bone surf (2E-2)	–	3E-14	3E-8	3E-7
		Y, see ^{244}Cf	–	3E-2	1E-11	4E-14	–	–
98	Californium-251	W, see ^{244}Cf	5E-1	4E-3	2E-12	–	–	–
			Bone surf (1E+0)	Bone surf (9E-3)	–	1E-14	2E-8	2E-7
		Y, see ^{244}Cf	–	1E-2	4E-12	–	–	–
				Bone surf				
			–	(1E-2)	–	2E-14	–	–
98	Californium-252	W, see ^{244}Cf	2E+0	2E-2	8E-12	–	–	–
			Bone surf (5E+0)	Bone surf (4E-2)	–	5E-14	7E-8	7E-7
		Y, see ^{244}Cf	–	3E-2	1E-11	5E-14	–	–
98	Californium-253	W, see ^{244}Cf	2E+2	2E+0	8E-10	3E-12	–	–
			Bone surf (4E+2)	–	–	–	5E-6	5E-5
		Y, see ^{244}Cf	–	2E+0	7E-10	2E-12	–	–
98	Californium-254	W, see ^{244}Cf	2E+0	2E-2	9E-12	3E-14	3E-8	3E-7
		Y, see ^{244}Cf	–	2E-2	7E-12	2E-14	–	–
99	Einsteinium-250	W, all compounds	4E+4	5E+2	2E-7	–	6E-4	6E-3
				Bone surf				
			–	(1E+3)	–	2E-9	–	–
99	Einsteinium-251	W, all compounds	7E+3	9E+2	4E-7	–	1E-4	1E-3
				Bone surf				
			–	(1E+3)	–	2E-9	–	–
99	Einsteinium-253	W, all compounds	2E+2	1E+0	6E-10	2E-12	2E-6	2E-5

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
99	Einsteinium-254m	W, all compounds	3E+2	1E+1	4E-9	1E-11	–	–
			LLI wall (3E+2)	–	–	–	4E-6	4E-5
99	Einsteinium-254	W, all compounds	8E+0 Bone surf (2E+1)	7E-2 Bone surf (1E-1)	3E-11 –	– 2E-13	– 2E-7	– 2E-6
100	Fermium-252	W, all compounds	5E+2	1E+1	5E-9	2E-11	6E-6	6E-5
100	Fermium-253	W, all compounds	1E+3	1E+1	4E-9	1E-11	1E-5	1E-4
100	Fermium-254	W, all compounds	3E+3	9E+1	4E-8	1E-10	4E-5	4E-4
100	Fermium-255	W, all compounds	5E+2	2E+1	9E-9	3E-11	7E-6	7E-5
100	Fermium-257	W, all compounds	2E+1 Bone surf (4E+1)	2E-1 Bone surf (2E-1)	7E-11 –	– 3E-13	– 5E-7	– 5E-6
101	Mendelevium-257	W, all compounds	7E+3	8E+1 Bone surf (9E+1)	4E-8 –	– 1E-10	1E-4 –	1E-3 –
101	Mendelevium-258	W, all compounds	3E+1 Bone surf (5E+1)	2E-1 Bone surf (3E-1)	1E-10 –	– 5E-13	– 6E-7	– 6E-6
- Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours		Submersion[a/]	–	2E+2	1E-7	1E-9	–	–
- Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours		. . . .	–	2E-1	1E-10	1E-12	1E-8	1E-7
- 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		. . . .	–	4E-4	2E-13	1E-15	2E-9	2E-8

Footnotes for Appendix G to Section 3:

[a/] "Submersion" means that values given are for submersion in a hemispherical semi-infinite cloud of airborne material.

[b/] 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 RH-1202.)

[c/] For soluble mixtures of U-238, U-234, and U-235 in air, chemical toxicity may be the limiting factor. (See RH-1200.e.) If the percent by weight (enrichment) of U-235 is not greater than 5, the concentration value for a 40-hour workweek is 0.2 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8E-3 (SA) μCi-hr/ml, where SA is the specific activity of the uranium inhaled. The specific activity for natural uranium is 6.77E-7 curies per gram U. The specific activity for other mixtures of U-238, U-235, and U-234, if not known, shall be:

SA = 3.6E-7 curies/gram U U-depleted

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

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

Note:

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

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

Footnotes for Appendix G to Section 3 (Cont'd)

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage

Radionuclide	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
	Col. 1 Oral Ingestion ALI (µCi)	Col. 2 Inhalation ALI (µCi)	Col. 3 Inhalation DAC (µCi/ml)	Col. 1 Air (µCi/ml)	Col. 2 Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
If it is known that Ac-227-D and Cm-250-W are not present	–	7E-4	3E-13	–	–	–
If, in addition, it is known that Ac-227-W,Y, Th-229-W,Y, Th-230-W, Th-232-W,Y, Pa-231-W,Y, Np-237-W, Pu-239-W, Pu-240-W, Pu-242-W, Am-241-W, Am-242m-W, Am-243-W, Cm-245-W, Cm-246-W, Cm-247-W, Cm-248-W, Bk-247-W, Cf-249-W, and Cf-251-W are not present	–	7E-3	3E-12	–	–	–
If, in addition, it is known that Sm-146-W, Sm-147-W, Gd-148-D,W, Gd-152-D,W, Th-228-W,Y, Th-230-Y, U-232-Y, U-233-Y, U-234-Y, U-235-Y, U-236-Y, U-238-Y, Np-236-W, Pu-236-W,Y, Pu-238-W,Y, Pu-239-Y, Pu-240-Y, Pu-242-Y, Pu-244-W,Y, Cm-243-W, Cm-244-W, Cf-248-W, Cf-249-Y, Cf-250-W,Y, Cf-251-Y, Cf-252-W,Y, and Cf-254-W,Y are not present	–	7E-2	3E-11	–	–	–
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	–	–

Footnotes for Appendix G to Section 3 (Cont'd)

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (continued)

	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
	Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
	Oral Ingestion	Inhalation				
Radionuclide	ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
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

Note (Cont'd):

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 G to Section 3 for the specific radionuclide when not in a mixture. The sum of such ratios for all of the radionuclides in the mixture may not exceed "1" (i.e., "unity").

   Example: If radionuclides "A," "B," and "C" are present in concentrations C_A, C_B, and C_C, and if the applicable DACs are DAC_A, DAC_B, and DAC_C, respectively, then the concentrations shall be limited so that the following relationship exists:

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

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

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

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Zinc-65	10	Bromine-74	1,000
Zinc-69m	100	Bromine-75	1,000
Zinc-69	1,000	Bromine-76	100
Zinc-71m	1,000	Bromine-77	1,000
Zinc-72	100	Bromine-80m	1,000
Gallium-65	1,000	Bromine-80	1,000
Gallium-66	100	Bromine-82	100
Gallium-67	1,000	Bromine-83	1,000
Gallium-68	1,000	Bromine-84	1,000
Gallium-70	1,000	Krypton-74	1,000
Gallium-72	100	Krypton-76	1,000
Gallium-73	1,000	Krypton-77	1,000
Germanium-66	1,000	Krypton-79	1,000
Germanium-67	1,000	Krypton-81	1,000
Germanium-68	10	Krypton-83m	1,000
Germanium-69	1,000	Krypton-85m	1,000
Germanium-71	1,000	Krypton-85	1,000
Germanium-75	1,000	Krypton-87	1,000
Germanium-77	1,000	Krypton-88	1,000
Germanium-78	1,000	Rubidium-79	1,000
Arsenic-69	1,000	Rubidium-81m	1,000
Arsenic-70	1,000	Rubidium-81	1,000
Arsenic-71	100	Rubidium-82m	1,000
Arsenic-72	100	Rubidium-83	100
Arsenic-73	100	Rubidium-84	100
Arsenic-74	100	Rubidium-86	100
Arsenic-76	100	Rubidium-87	100
Arsenic-77	100	Rubidium-88	1,000
Arsenic-78	1,000	Rubidium-89	1,000
Selenium-70	1,000	Strontium-80	100
Selenium-73m	1,000	Strontium-81	1,000
Selenium-73	100	Strontium-83	100
Selenium-75	100	Strontium-85m	1,000
Selenium-79	100	Strontium-85	100
Selenium-81m	1,000	Strontium-87m	1,000
Selenium-81	1,000	Strontium-89	10
Selenium-83	1,000	Strontium-90	0.1
Bromine-74m	1,000	Strontium-91	100

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Strontium-92	100	Technetium-94	1,000
Yttrium-86m	1,000	Technetium-96m	1,000
Yttrium-86	100	Technetium-96	100
Yttrium-87	100	Technetium-97m	100
Yttrium-88	10	Technetium-97	1,000
Yttrium-90m	1,000	Technetium-98	10
Yttrium-90	10	Technetium-99m	1,000
Yttrium-91m	1,000	Technetium-99	100
Yttrium-91	10	Technetium-101	1,000
Yttrium-92	100	Technetium-104	1,000
Yttrium-93	100	Ruthenium-94	1,000
Yttrium-94	1,000	Ruthenium-97	1,000
Yttrium-95	1,000	Ruthenium-103	100
Zirconium-86	100	Ruthenium-105	1,000
Zirconium-88	10	Ruthenium-106	1
Zirconium-89	100	Rhodium-99m	1,000
Zirconium-93	1	Rhodium-99	100
Zirconium-95	10	Rhodium-100	100
Zirconium-97	100	Rhodium-101m	1,000
Niobium-88	1,000	Rhodium-101	10
Niobium-89m (66 min)	1,000	Rhodium-102m	10
Niobium-89 (122 min)	1,000	Rhodium-102	10
Niobium-90	100	Rhodium-103m	1,000
Niobium-93m	10	Rhodium-105	100
Niobium-94	1	Rhodium-106m	1,000
Niobium-95m	100	Rhodium-107	1,000
Niobium-95	100	Palladium-100	100
Niobium-96	100	Palladium-101	1,000
Niobium-97	1,000	Palladium-103	100
Niobium-98	1,000	Palladium-107	10
Molybdenum-90	100	Palladium-109	100
Molybdenum-93m	100	Silver-102	1,000
Molybdenum-93	10	Silver-103	1,000
Molybdenum-99	100	Silver-104m	1,000
Molybdenum-101	1,000	Silver-104	1,000
Technetium-93m	1,000	Silver-105	100
Technetium-93	1,000	Silver-106m	100
Technetium-94m	1,000	Silver-106	1,000

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Silver-108m	1	Tin-127	1,000
Silver-110m	10	Tin-128	1,000
Silver-111	100	Antimony-115	1,000
Silver-112	100	Antimony-116m	1,000
Silver-115	1,000	Antimony-116	1,000
Cadmium-104	1,000	Antimony-117	1,000
Cadmium-107	1,000	Antimony-118m	1,000
Cadmium-109	1	Antimony-119	1,000
Cadmium-113m	0.1	Antimony-120 (16 min)	1,000
Cadmium-113	100	Antimony-120 (5.76 d)	100
Cadmium-115m	10	Antimony-122	100
Cadmium-115	100	Antimony-124m	1,000
Cadmium-117m	1,000	Antimony-124	10
Cadmium-117	1,000	Antimony-125	100
Indium-109	1,000	Antimony-126m	1,000
Indium-110 (69.1 min)	1,000	Antimony-126	100
Indium-110 (4.9 h)	1,000	Antimony-127	100
Indium-111	100	Antimony-128 (10.4 min)	1,000
Indium-112	1,000	Antimony-128 (9.01 h)	100
Indium-113m	1,000	Antimony-129	100
Indium-114m	10	Antimony-130	1,000
Indium-115m	1,000	Antimony-131	1,000
Indium-115	100	Tellurium-116	1,000
Indium-116m	1,000	Tellurium-121m	10
Indium-117m	1,000	Tellurium-121	100
Indium-117	1,000	Tellurium-123m	10
Indium-119m	1,000	Tellurium-123	100
Tin-110	100	Tellurium-125m	10
Tin-111	1,000	Tellurium-127m	10
Tin-113	100	Tellurium-127	1,000
Tin-117m	100	Tellurium-129m	10
Tin-119m	100	Tellurium-129	1,000
Tin-121m	100	Tellurium-131m	10
Tin-121	1,000	Tellurium-131	100
Tin-123m	1,000	Tellurium-132	10
Tin-123	10	Tellurium-133m	100
Tin-125	10	Tellurium-133	1,000
Tin-126	10	Tellurium-134	1,000

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Iodine-120m	1,000	Cesium-135	100
Iodine-120	100	Cesium-136	10
Iodine-121	1,000	Cesium-137	10
Iodine-123	100	Cesium-138	1,000
Iodine-124	10	Barium-126	1,000
Iodine-125	1	Barium-128	100
Iodine-126	1	Barium-131m	1,000
Iodine-128	1,000	Barium-131	100
Iodine-129	1	Barium-133m	100
Iodine-130	10	Barium-133	100
Iodine-131	1	Barium-135m	100
Iodine-132m	100	Barium-139	1,000
Iodine-132	100	Barium-140	100
Iodine-133	10	Barium-141	1,000
Iodine-134	1,000	Barium-142	1,000
Iodine-135	100	Lanthanum-131	1,000
Xenon-120	1,000	Lanthanum-132	100
Xenon-121	1,000	Lanthanum-135	1,000
Xenon-122	1,000	Lanthanum-137	10
Xenon-123	1,000	Lanthanum-138	100
Xenon-125	1,000	Lanthanum-140	100
Xenon-127	1,000	Lanthanum-141	100
Xenon-129m	1,000	Lanthanum-142	1,000
Xenon-131m	1,000	Lanthanum-143	1,000
Xenon-133m	1,000	Cerium-134	100
Xenon-133	1,000	Cerium-135	100
Xenon-135m	1,000	Cerium-137m	100
Xenon-135	1,000	Cerium-137	1,000
Xenon-138	1,000	Cerium-139	100
Cesium-125	1,000	Cerium-141	100
Cesium-127	1,000	Cerium-143	100
Cesium-129	1,000	Cerium-144	1
Cesium-130	1,000	Praseodymium-136	1,000
Cesium-131	1,000	Praseodymium-137	1,000
Cesium-132	100	Praseodymium-138m	1,000
Cesium-134m	1,000	Praseodymium-139	1,000
Cesium-134	10	Praseodymium-142m	1,000
Cesium-135m	1,000	Praseodymium-142	100

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Praseodymium-143	100	Europium-150 (12.62 h)	100
Praseodymium-144	1,000	Europium-150 (34.2 y)	1
Praseodymium-145	100	Europium-152m	100
Praseodymium-147	1,000	Europium-152	1
Neodymium-136	1,000	Europium-154	1
Neodymium-138	100	Europium-155	10
Neodymium-139m	1,000	Europium-156	100
Neodymium-139	1,000	Europium-157	100
Neodymium-141	1,000	Europium-158	1,000
Neodymium-147	100	Gadolinium-145	1,000
Neodymium-149	1,000	Gadolinium-146	10
Neodymium-151	1,000	Gadolinium-147	100
Promethium-141	1,000	Gadolinium-148	0.001
Promethium-143	100	Gadolinium-149	100
Promethium-144	10	Gadolinium-151	10
Promethium-145	10	Gadolinium-152	100
Promethium-146	1	Gadolinium-153	10
Promethium-147	10	Gadolinium-159	100
Promethium-148m	10	Terbium-147	1,000
Promethium-148	10	Terbium-149	100
Promethium-149	100	Terbium-150	1,000
Promethium-150	1,000	Terbium-151	100
Promethium-151	100	Terbium-153	1,000
Samarium-141m	1,000	Terbium-154	100
Samarium-141	1,000	Terbium-155	1,000
Samarium-142	1,000	Terbium-156m (5.0 h)	1,000
Samarium-145	100	Terbium-156m (24.4 h)	1,000
Samarium-146	1	Terbium-156	100
Samarium-147	100	Terbium-157	10
Samarium-151	10	Terbium-158	1
Samarium-153	100	Terbium-160	10
Samarium-155	1,000	Terbium-161	100
Samarium-156	1,000	Dysprosium-155	1,000
Europium-145	100	Dysprosium-157	1,000
Europium-146	100	Dysprosium-159	100
Europium-147	100	Dysprosium-165	1,000
Europium-148	10	Dysprosium-166	100
Europium-149	100	Holmium-155	1,000

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Holmium-157	1,000	Lutetium-176	100
Holmium-159	1,000	Lutetium-177m	10
Holmium-161	1,000	Lutetium-177	100
Holmium-162m	1,000	Lutetium-178m	1,000
Holmium-162	1,000	Lutetium-178	1,000
Holmium-164m	1,000	Lutetium-179	1,000
Holmium-164	1,000	Hafnium-170	100
Holmium-166m	1	Hafnium-172	1
Holmium-166	100	Hafnium-173	1,000
Holmium-167	1,000	Hafnium-175	100
Erbium-161	1,000	Hafnium-177m	1,000
Erbium-165	1,000	Hafnium-178m	0.1
Erbium-169	100	Hafnium-179m	10
Erbium-171	100	Hafnium-180m	1,000
Erbium-172	100	Hafnium-181	10
Thulium-162	1,000	Hafnium-182m	1,000
Thulium-166	100	Hafnium-182	0.1
Thulium-167	100	Hafnium-183	1,000
Thulium-170	10	Hafnium-184	100
Thulium-171	10	Tantalum-172	1,000
Thulium-172	100	Tantalum-173	1,000
Thulium-173	100	Tantalum-174	1,000
Thulium-175	1,000	Tantalum-175	1,000
Ytterbium-162	1,000	Tantalum-176	100
Ytterbium-166	100	Tantalum-177	1,000
Ytterbium-167	1,000	Tantalum-178	1,000
Ytterbium-169	100	Tantalum-179	100
Ytterbium-175	100	Tantalum-180m	1,000
Ytterbium-177	1,000	Tantalum-180	100
Ytterbium-178	1,000	Tantalum-182m	1,000
Lutetium-169	100	Tantalum-182	10
Lutetium-170	100	Tantalum-183	100
Lutetium-171	100	Tantalum-184	100
Lutetium-172	100	Tantalum-185	1,000
Lutetium-173	10	Tantalum-186	1,000
Lutetium-174m	10	Tungsten-176	1,000
Lutetium-174	10	Tungsten-177	1,000
Lutetium-176m	1,000	Tungsten-178	1,000

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Tungsten-179	1,000	Iridium-194m	10
Tungsten-181	1,000	Iridium-194	100
Tungsten-185	100	Iridium-195m	1,000
Tungsten-187	100	Iridium-195	1,000
Tungsten-188	10	Platinum-186	1,000
Rhenium-177	1,000	Platinum-188	100
Rhenium-178	1,000	Platinum-189	1,000
Rhenium-181	1,000	Platinum-191	100
Rhenium-182 (12.7 h)	1,000	Platinum-193m	100
Rhenium-182 (64.0 h)	100	Platinum-193	1,000
Rhenium-184m	10	Platinum-195m	100
Rhenium-184	100	Platinum-197m	1,000
Rhenium-186m	10	Platinum-197	100
Rhenium-186	100	Platinum-199	1,000
Rhenium-187	1,000	Platinum-200	100
Rhenium-188m	1,000	Gold-193	1,000
Rhenium-188	100	Gold-194	100
Rhenium-189	100	Gold-195	10
Osmium-180	1,000	Gold-198m	100
Osmium-181	1,000	Gold-198	100
Osmium-182	100	Gold-199	100
Osmium-185	100	Gold-200m	100
Osmium-189m	1,000	Gold-200	1,000
Osmium-191m	1,000	Gold-201	1,000
Osmium-191	100	Mercury-193m	100
Osmium-193	100	Mercury-193	1,000
Osmium-194	1	Mercury-194	1
Iridium-182	1,000	Mercury-195m	100
Iridium-184	1,000	Mercury-195	1,000
Iridium-185	1,000	Mercury-197m	100
Iridium-186	100	Mercury-197	1,000
Iridium-187	1,000	Mercury-199m	1,000
Iridium-188	100	Mercury-203	100
Iridium-189	100	Thallium-194m	1,000
Iridium-190m	1,000	Thallium-194	1,000
Iridium-190	100	Thallium-195	1,000
Iridium-192m (1.4 min)	10	Thallium-197	1,000
Iridium-192 (73.8 d)	1	Thallium-198m	1,000

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Thallium-198	1,000	Radon-220	1
Thallium-199	1,000	Radon-222	1
Thallium-200	1,000	Francium-222	100
Thallium-201	1,000	Francium-223	100
Thallium-202	100	Radium-223	0.1
Thallium-204	100	Radium-224	0.1
Lead-195m	1,000	Radium-225	0.1
Lead-198	1,000	Radium-226	0.1
Lead-199	1,000	Radium-227	1,000
Lead-200	100	Radium-228	0.1
Lead-201	1,000	Actinium-224	1
Lead-202m	1,000	Actinium-225	0.01
Lead-202	10	Actinium-226	0.1
Lead-203	1,000	Actinium-227	0.001
Lead-205	100	Actinium-228	1
Lead-209	1,000	Thorium-226	10
Lead-210	0.01	Thorium-227	0.01
Lead-211	100	Thorium-228	0.001
Lead-212	1	Thorium-229	0.001
Lead-214	100	Thorium-230	0.001
Bismuth-200	1,000	Thorium-231	100
Bismuth-201	1,000	Thorium-232	100
Bismuth-202	1,000	Thorium-234	10
Bismuth-203	100	Thorium-natural	100
Bismuth-205	100	Protactinium-227	10
Bismuth-206	100	Protactinium-228	1
Bismuth-207	10	Protactinium-230	0.1
Bismuth-210m	0.1	Protactinium-231	0.001
Bismuth-210	1	Protactinium-232	1
Bismuth-212	10	Protactinium-233	100
Bismuth-213	10	Protactinium-234	100
Bismuth-214	100	Uranium-230	0.01
Polonium-203	1,000	Uranium-231	100
Polonium-205	1,000	Uranium-232	0.001
Polonium-207	1,000	Uranium-233	0.001
Polonium-210	0.1	Uranium-234	0.001
Astatine-207	100	Uranium-235	0.001
Astatine-211	10	Uranium-236	0.001

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Uranium-237	100	Americium-246m	1,000
Uranium-238	100	Americium-246	1,000
Uranium-239	1,000	Curium-238	100
Uranium-240	100	Curium-240	0.1
Uranium-natural	100	Curium-241	1
Neptunium-232	100	Curium-242	0.01
Neptunium-233	1,000	Curium-243	0.001
Neptunium-234	100	Curium-244	0.001
Neptunium-235	100	Curium-245	0.001
Neptunium-236 (1.15E+5 y)	0.001	Curium-246	0.001
Neptunium-236 (22.5 h)	1	Curium-247	0.001
Neptunium-237	0.001	Curium-248	0.001
Neptunium-238	10	Curium-249	1,000
Neptunium-239	100	Berkelium-245	100
Neptunium-240	1,000	Berkelium-246	100
Plutonium-234	10	Berkelium-247	0.001
Plutonium-235	1,000	Berkelium-249	0.1
Plutonium-236	0.001	Berkelium-250	10
Plutonium-237	100	Californium-244	100
Plutonium-238	0.001	Californium-246	1
Plutonium-239	0.001	Californium-248	0.01
Plutonium-240	0.001	Californium-249	0.001
Plutonium-241	0.01	Californium-250	0.001
Plutonium-242	0.001	Californium-251	0.001
Plutonium-243	1,000	Californium-252	0.001
Plutonium-244	0.001	Californium-253	0.1
Plutonium-245	100	Californium-254	0.001
Americium-237	1,000	Einsteinium-250	100
Americium-238	100	Einsteinium-251	100
Americium-239	1,000	Einsteinium-253	0.1
Americium-240	100	Einsteinium-254m	1
Americium-241	0.001	Einsteinium-254	0.01
Americium-242m	0.001	Fermium-252	1
Americium-242	10	Fermium-253	1
Americium-243	0.001	Fermium-254	10
Americium-244m	100	Fermium-255	1
Americium-244	10	Fermium-257	0.01
Americium-245	1,000	Mendelevium-257	10

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
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

Note:

For purposes of RH-1310.a. and RH-1501.c. 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.

Footnotes for Appendix H to Section 3:

[a/] 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 G to Section 3, rounding to the nearest factor of 10, and constraining the values listed between 37 Bq and 37 MBq (0.001 and 1,000 μCi). Values of 3.7 MBq (100 μCi) have been assigned for radionuclides having a radioactive half-life in excess of E+9 years, except rhenium, 37 MBq (1,000 μCi), to take into account their low specific activity.

[b/] To convert μCi to kBq, multiply the μCi value by 37.

NOTICE TO EMPLOYEES

Arkansas Department of Health
STANDARDS FOR PROTECTION AGAINST RADIATION

The Arkansas Department of Health (ADH) has adopted regulations with standards to protect you from hazards associated with radioactive materials and radiation emitting machines which are licensed or registered by ADH. In particular, the following information is available for your review:

Section 3: Standards for Protection Against Radiation
Part N: Notice, Instructions, and Reports to Workers; Inspections
Any other documents your employer must provide.

These may be found at the following location:

YOUR EMPLOYER'S RESPONSIBILITY
Your employer is required to:

1. Comply with all applicable regulations and the conditions of the license or registration.

2. Post or otherwise make available to you a copy of the regulations, licenses, and operating procedures which apply to work in which you are engaged, and explain the provisions to you.

YOUR RESPONSIBILITY AS A WORKER
You should:

1. Know the provisions of the ADH regulations, the precautions, the operating procedures, and the emergency procedures which apply to your work.

2. Observe the provisions for your own protection and for the protection of your co-workers.

3. Report unsafe working conditions or violations of the license or registration conditions or regulations to ADH.

REPORTS OF YOUR RADIATION EXPOSURE HISTORY

1. The ADH regulations specify the occupational limits for radiation exposure including concentrations of radioactive material in air and water. These regulations require your employer to give you a written report if you receive exposure in excess of any applicable limit. The limits on your exposure are contained in RH-1200, RH-1206, and RH-1207. While these are the maximum allowable limits, your employer should keep your radiation exposure below those limits as is reasonably achievable.

2. If you work where personnel monitoring is required and request information on your radiation exposures,

    a. your employer must advise you annually of your exposure to radiation, and
    b. upon termination of employment, your employer must give you a written report of your radiation exposures.
    c. A report of any exposure in excess of a limit must be reported to you.

INSPECTIONS: All licensed or registered activities are subject to inspection by the ADH.

INQUIRIES

Direct all inquiries on matters outlined above to: ADH, Radiation Control Section, 4815 West Markham Street, Slot 30, Little Rock, Arkansas, 72205-3867 or to (501)661-2301. For emergencies, call (800) 633-1735.

POSTING REQUIREMENT: In accordance with RH-2802, copies of this notice must be posted in every establishment where employees are engaged in activities licensed or registered by the ADH. Posting must permit employees working in or frequenting any portion of a restricted area to observe a copy on the way to or from their place of employment.

APPENDIX K TO SECTION 3

Deleted.

APPENDIX L TO SECTION 3

Deleted.

FOOTNOTES TO SECTION 3

1/ 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 ten percent (10%) of the maximum weighted value of $H_{T,50}$ (i.e., $W_T H_{T,50}$) per unit intake for any organ or tissue. $H_{T,50}$ was H_{50}.

2/ This section applies to radiation from byproduct, source, or special nuclear materials that are used in sealed sources in non-self-shielded irradiators. This section does not apply to radioactive sources that are used in teletherapy, in industrial radiography, or in completely self-shielded irradiators in which the source is both stored and operated within the same shielding radiation barrier and, in the designed configuration of the irradiator cannot create high levels of radiation in an area that is accessible to any individual. This section also does not apply to sources from which the radiation is incidental to some other use or to nuclear reactor-generated radiation.

3/ Deleted.

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

5/ Labeling of packages containing radioactive materials is required by the Department of Transportation (DOT) if the amount and type of radioactive material exceeds the limits for an excepted quantity or article as defined and limited by DOT regulations 49 CFR 173.403 and 173.421-426.

6/ Licensees are not required to partition historical dose between external dose equivalent(s) and internal committed dose equivalent(s). Further, occupational exposure histories obtained and recorded on RC FORM 111 (formerly known as Department Form Z or Department Form RH-1), or equivalent, before January 1, 1994, might not have included effective dose equivalent, but may be used in the absence of specific information on the intake of radionuclides by the individual.

7/ Assessments of dose equivalent and records made using units in effect before the licensee's adoption of this Section need not be changed.

8/ A previous RH-1403. permitted certain burials of small quantities of licensed materials in soil before January 1, 1983, without specific Department authorization. As of January 1, 1983, these burials had to receive specific approval by the Department, in accordance with the revised RH-1403. Disposal by burial in soil came to be regulated under RH-1401.

9/ With respect to the limit for the embryo/fetus (RH-1207), the identifiers should be those of the declared pregnant woman.

10/ Deleted.

11/ The nominal chemical composition of type 1100 aluminum alloy is 99.00 percent (99%) minimum aluminum, 0.12 percent copper.

12/ Deleted.

13/ Deleted.

14/ An example of a suggested plaque is shown at the end of this Part.

15/ Appropriate warnings may include:

a. "Do not drill below plug back depth";

b. "Do not enlarge casing"; or

c. "Do not re-enter the hole," followed by the words, "before contacting the Arkansas Department of Health."