EFFECTIVE RADIOACTIVE WASTE MANAGEMENT AT MEDICAL AND ACADEMIC INSTITUTIONS

Prepared by
Division of Fuel Cycle and Material Safety
Nuclear Regulatory Commission

A shortfall in commercial low-level radioactive waste disposal capacity has developed over the past two years. It is anticipated that disposal capacity will not increase over the next several years and could, in the short-term, be reduced still further. Costs for commercial disposal have significantly increased. The combination of capacity shortfall and costs is reported to have caused some curtailment in research and development uses of radioisotopes at medical and academic institutions.

The purpose of this paper is to outline steps which can be taken now to reduce the volume of radioactive waste which must be sent to commercial low-level radioactive waste burial sites. The NRC staff believes that in many instances medical and academic institutions can realize substantial volume reduction, perhaps as much as 50 percent, for such waste if good waste management practices are followed.

The attached Flowchart outlines schematically basic steps for effective waste management at medical and academic institutions. Each step is discussed in turn below.

I. Minimize Waste Generation

Work involving radioactive materials should be carefully planned to minimize the volume of waste generated. Heretofore, little attention has been given to minimizing the volume of waste generated because it takes time and there was little incentive to do so. Minimizing the generation of radioactive waste simply requires administrative procedures for careful preplanning of work, effective management control, and care in the use of radioactive materials.

II. Segregation of Radioactive Waste

Most laboratories generate several types of waste streams in the course of conducting their work. Segregation will lead to a volume reduction of the radioactive waste which eventually must go to commercial burial grounds. To assure appropriate waste segregation, administrative procedures, effective management, and care is needed. The major actions leading to minimization of radioactive waste generation, typical of medical and academic institutions, are described below, each of which can be treated differently.

- Non-Radioactive Waste

The first step in waste segregation is to assure that waste treated as radioactive waste is, in fact, radioactive waste. Care must be exercised to separate radioactive waste from non-radioactive waste as it is generated. Heretofore, because it was easier and the cost was not prohibitive, there was little incentive to exercise control in this manner. Rather, many laboratories treated as radioactive any waste associated with the use of radioactive material. Again, administrative procedures, effective management, and care is needed to be certain that non-radioactive waste is separated from radioactive. The non-radioactive waste, of course, should be disposed of in normal waste channels.

- Radioisotopes With Short Half-Lives

The attached table contains a list of commonly used radioisotopes in medical facilities which have relatively short half-lives. If waste containing these radioisotopes is held for decay for approximately 10 half-lives, it normally reaches background levels, i.e., the radioactivity cannot be distinguished from background with typical laboratory survey instruments. Once the waste has been stored through approximately 10 half-lives and reaches background levels, it can be disposed of through normal trash channels.

Holding materials for decay does require storage space. Most institutions can find sufficient storage space to hold for decay those wastes with less than 35 day half-lives. Longer half-lived materials often utilize too much storage space for this procedure to be of practical value. Also, biologic materials present a storage problem because they must often be refrigerated and, therefore, this procedure might not be practical for such wastes.

Special license approval under the provisions of 10 CFR 20.302 is required to hold materials for decay prior to disposal in normal trash. For consideration for such approval the applicant must demonstrate that (a) the material can be held safely, (b) an appropriate survey meter or other methods are used to confirm that waste has approched background levels prior to disposal as normal trash, and (c) administrative procedures assure proper surveys are made (See Enclosure 1 for more specific information needed in support of a license amendment.)

- Use of Sanitary Sewerage Systems

10 CFR 20.303 allows the release of radioactive materials under certain conditions into the sanitary sewerage system. No specific license approval is needed to do so. There are certain limitations on what may be released into the sanitary sewerage system. They are:

a. The effluents must be soluble and dispersible in water.

b. Radioactivity must not exceed in one day the concentration limits specified in Appendix B, Table I, Column 2, 10 CFR Part 20 considering dilution by daily quantity of sewage, or 10 times the amounts shown in Appendix C, 10 CFR Part 20, whichever is greater.

c. The average radioactive concentration of releases in any one month must not exceed the limits specified in Appendix B, Table I, Column 2, 10 CFR Part 20 considering dilution by average monthly quantity of sewage.

d. The gross quantity of radioactive material must not exceed one curie per year.

In addition to that which had previously been allowed under the provisions of 10 CFR 20.303, the Commission recently approved an amendment to this Section which would raise the limit of tritium to five curies per year and carbon-14 to one curie per year (with the concentration limits unchanged) in addition to the one curie limit for all other radioactive isotopes which presently exists. This rule is in effect as of March 11, 1981.

III Scintillation Fluids and Animal Carcasses Containing Tritium and Carbon-14

A proposed new Section, 20.306, to 10 CFR 20 became effective on March 11, 1981. It permits the disposal of scintillation fluids and animal carcasses containing less than 0.05 μCi/gr of tritium and carbon-14 to

be disposed of as non-radioactive waste. This rule allows institutions to dispose of these materials under certain conditions as though they did not contain radioactivity. However, since scintillation fluids are chemically hazardous and some biologic materials may be pathogenic, there are other federal, state or local laws with which the licensee must comply governing their disposal as non-radioactive material.

The NRC staff estimates that scintillation fluids and animal carcasses containing tritium and carbon-14 constitute 52 percent of the total volume of institutional waste now being sent to commercial low-level waste burial grounds. If they are treated as non-radioactive waste, in addition to realizing substantial volume reduction, institutions nationwide will realize a cost of savings of about 13 million dollars associated with packaging materials and disposal charges alone.

o Bulk Radioactive Trash

After separating the waste streams previously described, there will remain bulk radioactive trash to be managed. Depending on the amount of volume in any given institution, further steps might be appropriate to reduce that volume. Two volume reduction steps which may be appropriate for most institutions consist of compaction and incineration. Compaction can be accomplished rather simply by careful packaging procedures or by the use of mechanical compactors. Mechanical compactors, of course, involve some capital investment. Compaction requires carefully defined radiation safety procedures. Some level of compaction is probably appropriate for most institutions.

Incineration requires capital investment unless the institution already has an incinerator that can be used for this purpose. Incineration of radioactive waste requires a license amendment under the provisions of 10 CFR 20.305. (See Enclosure 2 for information which is required to support such an application for amendment.) Incineration requires good radiation control procedures and monitoring to assure both worker safety and control of materials released through the stack. Institutions considering incineration should be aware that some state and local laws may prohibit such activity.

If an institution's bulk waste volume is large, incineration can substantially reduce the total volume of radioactive waste that must be disposed of by some other technique.

- Burial in Soil on Licensee's Site

A license amendment may be applied for under the provisions of 10 CFR 20.302 (new rule effective by February 1981) for burial of small quantities of materials on a licensee's site. Generally, such application must demonstrate that the site is suitable and is controlled and at such time as the institution may abandon the site, no further control is needed for purposes of radiation protection over the unrestricted use of the on-site burial ground under conservatively postulated circumstances. Use of this provision is limited but may have application in certain instances. For example, it may offer a way to dispose of large animals, agricultural products, or ash from incinerators containing very low concentrations of tritium and carbon-14. An obvious consideration in this provision is that a licensee must have a suitable burial site and be prepared to dedicate the ground for this purpose, thus precluding alternative uses.

- Other Methods of Disposal

10 CFR 20.302 contains provisions which allow any licensee to propose additional methods for disposal of waste. The NRC staff has outlined the above methods which, in its experience, are practical for most medical and academic institutions. However, there may be other methods involving certain types of waste streams that are practical and safe for waste disposal. These can be proposed for consideration under the provisions of 10 CFR 20.302.

- Commercial Waste Disposal

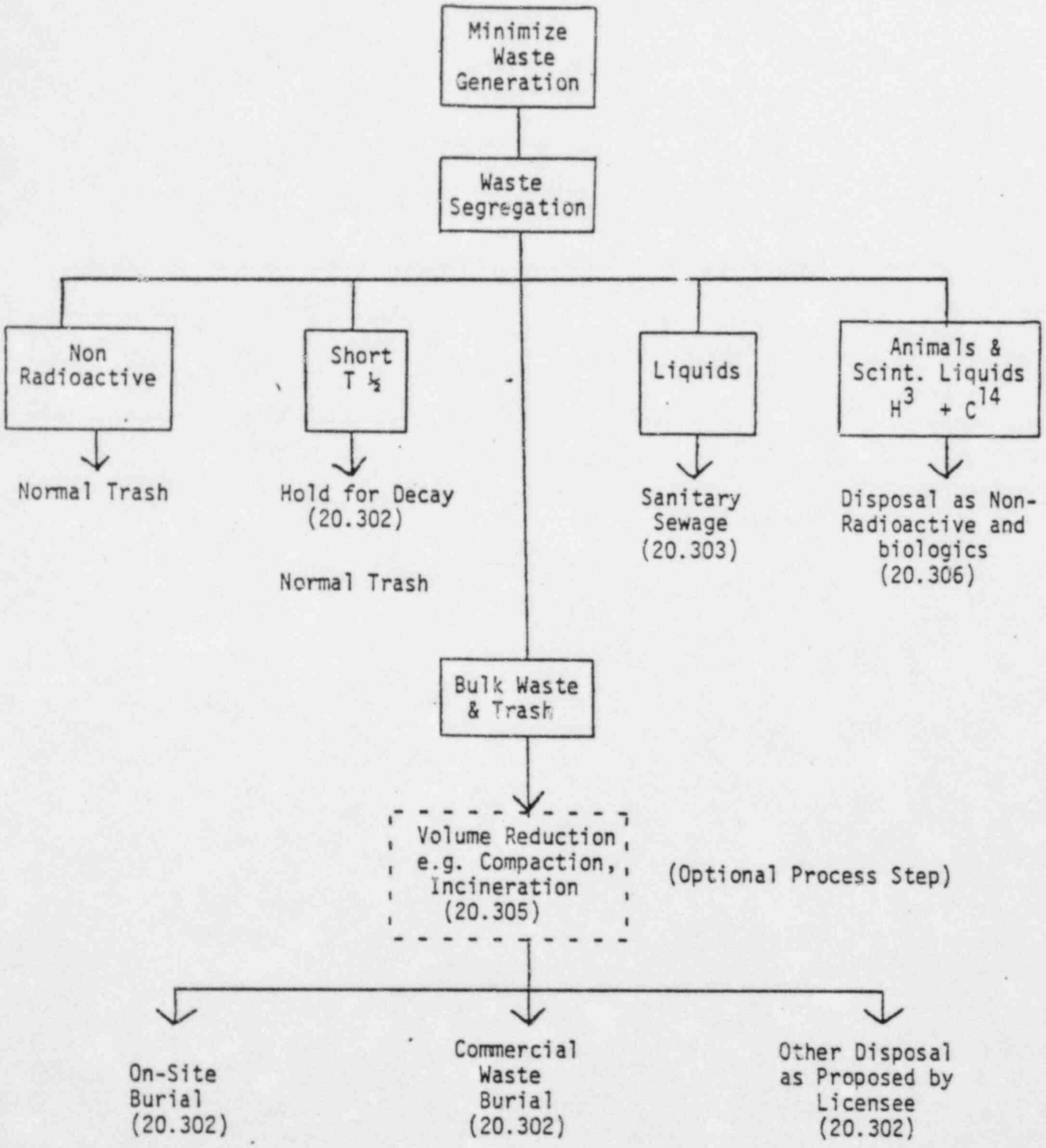
Whatever waste remains after the procedures outlined above have been followed generally needs to be sent to commercial low-level waste burial grounds. The NRC staff believes, however, that by careful attention to management controls and by taking full advantage of existing provisions of the regulations, many institutions can realize substantial volume reduction in the waste which they now send to burial grounds.

Attachments:
Flow Chart
Table

Enclosures:
1. Information to be Submitted When Requesting Amendment to Dispose of Radioactive Waste by Decay-in-Storage Method
2. NRC Considers Changes to Regulations on Disposal of Radioactive Wastes Resulting from Medical Research
3. Information Required for Commission Approval of Treatment or Disposal by Incineration

FLOW CHART

PROCEDURES FOR EFFECTIVE WASTE MANAGEMENT



TABLE

Examples of Short-Lived Isotopes Suitable For Hold-to-Decay Method

Isotope	Half-Life
Tc-99m	6 h*
Mo^{99}	67 h
Na-24	14-15 h
P-32	14 d**
P-33	24-25 d
K-42	12 1/2 h
Cr-51	28 d
I-131	8.05 d
I-133	20.3 h

* h = hours
** d = days

INFORMATION TO BE SUBMITTED WHEN REQUESTING AMENDMENT TO DISPOSE OF RADIOACTIVE WASTE BY DECAY-IN-STORAGE METHOD

This is in reference to your request for information concerning authorization to dispose of radioactive waste via decay-in-storage. In order to approve such an amendment request, we need the following information:

1. Please submit a diagram of the area where the waste will be decayed-in-storage. Show the type, location, and thickness of shielding that you will have available in this area on your diagram. Your storage area should be large enough to handle an accumulation of used Tc-99m generators as well as other solid waste.

   Identify adjacent unrestricted areas located across the walls from the storage area and show that adequate steps have been taken to assure that radiation levels do not exceed the limits specified in 10 CFR 20.105 (enclosed).

2. Describe your security measures for the decay-in-storage area.

3. Confirm that radiation levels in this area will be surveyed and recorded at least weekly.

4. Describe your procedures for monitoring the waste to assure that it has decayed to background levels prior to disposal. As a minimum, your description should include these points:

   a. Monitor the waste in a low background area.

   b. Monitor with a low level GM type survey meter as appropriate for contamination surveys. Use the most sensitive scale.

   c. Remove all shielding prior to monitoring.

   d. Maintain records of these surveys as required under 10 CFR 20.

5. Note that decay-in-storage may not be a practical method of disposal for Tc-99m generators. These generators may contain long-lived radioisotopic contaminants. If you intend to dispose of generators by this method, you should include procedures for segregating the generator columns so that they can be monitored separately.

Be certain to submit your amendment request in duplicate. Unless your institution is fee exempt, your request should be accompanied by the appropriate amendment fee. Refer to 10 CFR 170.

Enclosure 1

PART 20

STANDARDS FOR PROTECTION AGAINST RADIATION

GENERAL PROVISIONS

PERMISSIBLE DOSES, LEVELS, AND CONCENTRATIONS

PRECAUTIONARY PROCEDURES

WASTE DISPOSAL

RECORDS, REPORTS, AND NOTIFICATION

EXCEPTIONS AND ADDITIONAL REQUIREMENTS

ENFORCEMENT

AUTHORITY: The provisions of this Part 20 issued under secs. 53, 63, 65, 81, 103, 104, 161, 68 Stat. 930, 933, 935, 936, 937, 948, as amended; 42 U.S.C. 2073, 2093, 2095, 2111, 2133, 2134, 2201. For the purposes of sec. 223, 68 Stat. 958, as amended; 42 U.S.C. 2273, §§ 20.401-20.409, issued under sec. 161 o., 68 Stat. 950, as amended; 42 U.S.C. 2201 (o). Secs. 202, 206, Pub. L. 93-438, 88 Stat. 1244, 1246 (42 U.S.C. 5842, 5846).

[Sec. 81, 161b, Pub. L. 83-703, 68 Stat. 935, 948 as amended (42 U.S.C. 2111, 2201); Sec. 201, Pub. L. 93-438, 88 Stat. 1242 (42 U.S.C. 5841)]

[Section 161b., 161o., Pub. L. 83-703, 68 Stat. 948, 950 (42 U.S.C. 2201); Sec. 201, as amended, Pub. L. 93-438, 88 Stat. 1243, Pub. L. 94-79, 89 Stat. 413 (42 U.S.C. 5841); Memorandum of Understanding between the Environmental Protection Agency and the Atomic Energy Commission, August 1973, 38 FR 24936, September 11, 1973)

40 FR 8774

§ 20.1 Purpose.

(a) The regulations in this part establish standards for protection against radiation hazards arising out of activities under licenses issued by the Nuclear Regulatory Commission and are issued pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974.

44 FR 32332

(b) The use of radioactive material or other source(s) of radiation not licensed by the Commission is not subject to the regulations in this part. However, it is the purpose of the regulations in this part to control the possession, use, and transfer of licensed material by any licensee in such a manner that the total dose to an individual (including exposures to licensed and unlicensed radioactive material and to other unlicensed sources of radiation, whether in the possession of the licensee or any other person, but not including exposures to radiation from natural background sources or medical diagnosis and therapy) does not exceed the standards of radiation protection prescribed in the regulations in this part.

(c) In accordance with recommendations of the Federal Radiation Council, approved by the President, persons engaged in activities under licenses issued by the Nuclear Regulatory Commission pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974 should, in addition to complying with the requirements set forth in this part, make every reasonable effort to maintain radiation exposures, and releases of radioactive materials in effluents to unrestricted areas, as low as is reasonably achievable. The term "as low as is reasonably achievable" means as low as is reasonably achievable taking into account the state of technology, and the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to the utilization of atomic energy in the public interest.

40 FR 58847

§ 20.2 Scope.

The regulations in this part apply to all persons who receive, possess, use, or transfer material licensed pursuant to the regulations in Parts 30 through 35, 40, 60 or 70 of this chapter, including persons licensed to operate a production or utilization facility pursuant to Part 50 of this chapter.

46 FR 13971

§ 20.3 Definitions.

(a) As used in this part:

(1) "Act" means the Atomic Energy Act of 1954 (68 Stat. 919) including any amendments thereto;

40 FR 8774

(2) "Airborne radioactive material" means any radioactive material dispersed in the air in the form of dusts, fumes, mists, vapors, or gases;

(3) "Byproduct material" means any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material;

40 FR 42567

(4) "Calendar quarter" means not less than 12 consecutive weeks nor more than 14 consecutive weeks. The first calendar quarter of each year shall begin in January and subsequent calendar quarters shall be such that no day is included in more than one calendar quarter or omitted from inclusion within a calendar quarter. No licensee shall change the method observed by him of determining calendar quarters except at the beginning of a calendar year.

(5) "Commission" means the Nuclear Regulatory Commission or its duly authorized representatives.

the body. When the regulations in this part specify a dose during a period of time, the dose means the total quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body during such period of time. Several different units of dose are in current use. Definitions of units as used in this part are set forth in paragraphs (b) and (c) of this section.

(b) The rad, as used in this part, is a measure of the dose of any ionizing radiation to body tissues in terms of the energy absorbed per unit mass of the tissue. One rad is the dose corresponding to the absorption of 100 ergs per gram of tissue. (One millirad (mrad) = 0.001 rad.)

(c) The rem, as used in this part, is a measure of the dose of any ionizing radiation to body tissue in terms of its estimated biological effect relative to a dose of one roentgen (r) of X-rays. (One millirem (mrem) = 0.001 rem.) The relation of the rem to other dose units depends upon the biological effect under consideration and upon the conditions of irradiation. For the purpose of the regulations in this part, any of the following is considered to be equivalent to a dose of one rem:

(1) A dose of 1 r due to X— or gamma radiation;

(2) A dose of 1 rad due to X—, gamma, or beta radiation;

(3) A dose of 0.1 rad due to neutrons or high energy protons;

(4) A dose of 0.05 rad due to particles heavier than protons and with sufficient energy to reach the lens of the eye;

If it is more convenient to measure the neutron flux, or equivalent, than to determine the neutron dose in rads, as provided in subparagraph (3) of this paragraph, one rem of neutron radiation may, for purposes of the regulations in this part, be assumed to be equivalent to 14 million neutrons per square centimeter incident upon the body; or, if there exists sufficient information to estimate with reasonable accuracy the approximate distribution in energy of the neutrons, the incident number of neutrons per square centimeter equivalent to one rem may be estimated from the following table:

Neutron Flux Dose Equivalents

Neutron energy (Mev)	Number of neutrons per square centimeter equivalent to a dose of 1 rem (neutrons/cm²)	Average flux to deliver 100 millirems in 40 hours (neutrons/cm² per sec.)
Thermal	970 x 10⁶	670
0.0001	720 x 10⁶	500
0.005	820 x 10⁶	570
0.02	400 x 10⁶	280
0.1	120 x 10⁶	80
0.5	43 x 10⁶	30
1.0	26 x 10⁶	18
2.5	29 x 10⁶	20
5.0	25 x 10⁶	18
7.5	24 x 10⁶	17
10	24 x 10⁶	17
10 to 30	14 x 10⁶	10

(d) For determining exposures to X or gamma rays up to 3 Mev, the dose limits specified in §§ 20.101 to 20.104, inclusive, may be assumed to be equivalent to the "air dose". For the purpose of this part "air dose" means that the dose is measured by a properly calibrated appropriate instrument in air at or near the body surface in the region of highest dosage rate.

25 FR 10914

§ 20.5 Units of radioactivity.

(a) Radioactivity is commonly, and for purposes of the regulations in this part shall be, measured in terms of disintegrations per unit time or in curies. One curie = 3.7×10^{10} disintegrations per second (dps) = 2.2×10^{12} disintegrations per minute (dpm). Commonly used submultiples of the curie are the millicurie and the microcurie:

(1) One millicurie (mCi) [1] = 0.001 curie (Ci) [1] = 3.7×10^{7} dps.

(2) One microcurie (μCi) [1] = 0.000001 curie = 3.7×10^{4} dps.

(b) [Deleted 40 FR 50704.]

(c) [Deleted 39 FR 23990.]

38 FR 29314

§ 20.6 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

25 FR 10914

§ 20.7 Communications.

Except where otherwise specified in this part, all communications and reports concerning the regulations in this part should be addressed to the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555. Communications, reports, and applications may be delivered in person at the Commission's offices at 1717 H Street NW., Washington, D.C.; or at 7920 Norfolk Avenue, Bethesda, Maryland.

40 FR 8774

** Permissible Doses, Levels, and Concentrations

44 FR 32352

§ 20.101 Radiation dose standards for individuals in restricted areas.

(a) In accordance with the provisions of § 20.102(a), and except as provided in paragraph (b) of this section, no licensee shall possess, use, or transfer licensed material in such a manner as to cause any individual in a restricted area to receive in any period of one calendar quarter from radioactive material and other sources of radiation a total occupational dose in excess of the standards specified in the following table:

Rems per calendar quarter

1. Whole body; head and trunk; active blood-forming organs; lens of eyes; or gonads	1¼
2. Hands and forearms; feet and ankles	18¾
3. Skin of whole body	7½

25 FR 10914

(b) A licensee may permit an individual in a restricted area to receive a total occupational dose to the whole body greater than that permitted under paragraph (a) of this section, provided:

(1) During any calendar quarter the total occupational dose to the whole body shall not exceed 3 rems; and

(2) The dose to the whole body, when added to the accumulated occupational dose to the whole body, shall not exceed 5 (N–18) rems where "N" equals the individual's age in years at his last birthday; and

(3) The licensee has determined the individual's accumulated occupational dose to the whole body on Form NRC-4, or on a clear and legible record containing all the information required in that form; and has otherwise complied with the requirements of § 20.102. As used in paragraph (b), "Dose to the whole body" shall be deemed to include any dose to the whole body, gonads, active blood-forming organs, head and trunk, or lens of eye.

25 FR 10914

§ 20.102 Determination of prior dose.

44 FR 32352

(a) Each licensee shall require any individual, prior to first entry of the individual into the licensee's restricted area during each employment or work assignment under such circumstances that the individual will receive or is likely to receive in any period of one calendar quarter an occupational dose in excess of 25 percent of the applicable standards specified in § 20.101(a) and § 20.104(a), to disclose in a written, signed statement, either (1) that the individual had no prior occupational dose during the current calendar quarter, or (2) the nature and amount of any occupational dose which the individual may have received during that specifically identified current calendar quarter from sources of radiation possessed or controlled by other persons. Each licensee shall maintain records of such statements until the Commission authorizes their disposition.

(b) Before permitting, pursuant to § 20.101(b), any individual in a restricted area to receive an occupational radiation dose in excess of the standards specified in § 20.101(a), each licensee shall:

(1) Obtain a certificate on Form NRC-4, or on a clear and legible record containing all the information required in that form, signed by the individual showing each period of time after the individual attained the age of 18 in which the individual received an occupational dose of radiation; and

25 FR 10914

(2) Calculate on Form NRC-4 in accordance with the instructions appearing therein, or on a clear and legible record containing all the information required in that form, the previously accumulated occupational dose received by the individual and the additional dose allowed for that individual under § 20.101(b).

[1] Wherever possible, the appropriate unit should be written out as "curie(s)," "millicurie(s)," or "microcurie(s)," and the abbreviations should not be used.

** Amended 36 FR 1466.

limit concentrations of radioactive material in air below those defined in § 20.203(d)(1)(ii), other precautionary procedures, such as increased surveillance, limitation of working times, or provision of respiratory protective equipment, shall be used to maintain intake of radioactive material by any individual within any period of seven consecutive days as far below that intake of radioactive material which would result from inhalation of such material for 40 hours at the uniform concentrations specified in Appendix B, Table I, Column 1 as is reasonably achievable. Whenever the intake of radioactive material by any individual exceeds this 40-hour control measure, the licensee shall make such evaluations and take such actions as are necessary to assure against recurrence. The licensee shall maintain records of such occurrences, evaluations, and actions taken in a clear and readily identifiable form suitable for summary review and evaluation.

(c) When respiratory protective equipment is used to limit the inhalation of airborne radioactive material pursuant to paragraph (b)(2) of this section, the licensee may make allowance for such use in estimating exposures of individuals to such materials provided that such equipment is used as stipulated in Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection."*

(d) Notwithstanding the provisions of paragraphs (b) and (c) of this section, the Commission may impose further restrictions:

(1) On the extent to which a licensee may make allowance for use of respirators in lieu of provision of process, containment, ventilation, or other engineering controls, if application of such controls is found to be practicable; and

(2) As might be necessary to assure that the respiratory protective program of the licensee is adequate in limiting exposures of personnel to airborne radioactive materials.

(e) The licensee shall notify, in writing, the Director of the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix D at least 30 days before the date that respiratory protective equipment is first used under the provisions of this section.

(f) A licensee who was authorized to make allowance for use of respiratory protective equipment prior to December 29, 1976 shall bring his respiratory protective program into conformance with the requirements of paragraph (c) of this section within one year of that date, and is exempt from the requirement of paragraph (e) of this section.

*This incorporation by reference provision was approved by the Director of the Federal Register on October 19, 1976. Single copies of Regulatory Guide 8.15 are available from the Office of Standards Development, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, upon written request.

41 FR 52300

§ 20.104 Exposure of minors.

(a) No licensee shall possess, use or transfer licensed material in such a manner as to cause any individual within a restricted area who is under 18 years of age, to receive in any period of one calendar quarter from radioactive material and other sources of radiation in the licensee's possession a dose in excess of 10 percent of the limits specified in the table in paragraph (a) of § 20.101.

25 FR 10914

(b) No licensee shall possess, use or transfer licensed material in such a manner as to cause any individual within a restricted area, who is under 18 years of age to be exposed to airborne radioactive material possessed by the licensee in an average concentration in excess of the limits specified in Appendix B, Table II of this part. For purposes of this paragraph, concentrations may be averaged over periods not greater than a week.

41 FR 52300

(c) The provisions of §§ 20.103(b)(2) and 20.103(c) shall apply to exposures subject to paragraph (b) of this section except that the references in §§ 20.103(b)(2) and 20.103(c) to Appendix B, Table I, Column 1 shall be deemed to be references to Appendix B, Table II, Column 1.

§ 20.105 Permissible levels of radiation in unrestricted areas.

25 FR 10914

(a) There may be included in any application for a license or for amendment of a license proposed limits upon levels of radiation in unrestricted areas resulting from the applicant's possession or use of radioactive material and other sources of radiation. Such applications should include information as to anticipated average radiation levels and anticipated occupancy times for each unrestricted area involved. The Commission will approve the proposed limits if the applicant demonstrates that the proposed limits are not likely to cause any individual to receive a dose to the whole body in any period of one calendar year in excess of 0.5 rem.

(b) Except as authorized by the Commission pursuant to paragraph (a) of this section, no licensee shall possess, use or transfer licensed material in such a manner as to create in any unrestricted area from radioactive material and other sources of radiation in his possession:

(1) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of two millirems in any one hour, or

(2) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of 100 millirems in any seven consecutive days.

46 FR 18525

(c) In addition to other requirements of this part, licensees engaged in uranium fuel cycle operations subject to the provisions of 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," shall comply with that part.

29 FR 14434

§ 20.106 Radioactivity in effluents to unrestricted areas.

(a) A licensee shall not possess, use, or transfer licensed material so as to release to an unrestricted area radioactive material in concentrations which exceed the limits specified in Appendix "B", Table II of this part, except as authorized pursuant to § 20.302 or paragraph (b) of this section. For purposes of this section concentrations may be averaged over a period not greater than one year.

(b) An application for a license or amendment may include proposed limits higher than those specified in paragraph (a) of this section. The Commission will approve the proposed limits if the applicant demonstrates:

(1) That the applicant has made a reasonable effort to minimize the radioactivity contained in effluents to unrestricted areas; and

(2) That it is not likely that radioactive material discharged in the effluent would result in the exposure of an individual to concentrations of radioactive material in air or water exceeding the limits specified in Appendix "B", Table II of this part.

(c) An application for higher limits pursuant to paragraph (b) of this section shall include information demonstrating that the applicant has made a reasonable effort to minimize the radioactivity discharged in effluents to unrestricted areas, and shall include, as pertinent:

(1) Information as to flow rates, total volume of effluent, peak concentration of each radionuclide in the effluent, and concentration of each radionuclide in the effluent averaged over a period of one year at the point where the effluent leaves a stack, tube, pipe, or similar conduit;

(2) A description of the properties of the effluents, including:

(i) chemical composition;

(ii) physical characteristics, including suspended solids content in liquid effluents, and nature of gas or aerosol for air effluents;

(iii) the hydrogen ion concentrations (pH) of liquid effluents; and

(iv) the size range of particulates in effluents released into air.

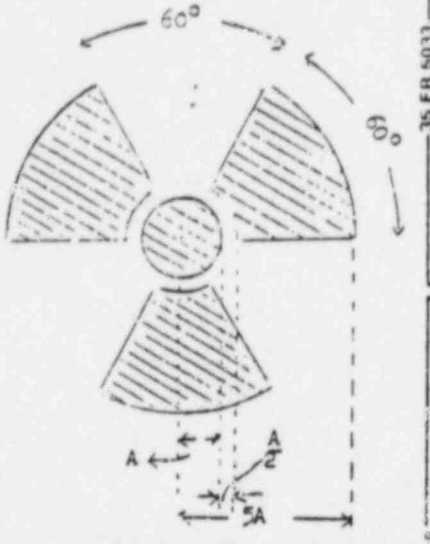
(3) A description of the anticipated human occupancy in the unrestricted area where the highest concentration of radioactive material from the effluent is expected, and, in the case of a river or stream, a description of water uses downstream from the point of release of the effluent.

(4) Information as to the highest concentration of each radionuclide in an unrestricted area, including anticipated concentrations averaged over a period of one year:

(i) In air at any point of human occupancy; or

RADIATION SYMBOL

1. Cross-hatched area is to be magenta or purple.
2. Background is to be yellow.



(2). In addition to the contents of signs and labels prescribed in this section, licensees may provide on or near such signs and labels any additional information which may be appropriate in aiding individuals to minimize exposure to radiation or to radioactive material.

(b) *Radiation areas.* Each radiation area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION
RADIATION AREA

(c) *High radiation areas.* (1) Each high radiation area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION
HIGH RADIATION AREA

35 FR 5033

(2) Each entrance or access point to a high radiation area shall be:

(i) Equipped with a control device which shall cause the level of radiation to be reduced below that at which an individual might receive a dose of 100 millirems in 1 hour upon entry into the area; or

(ii) Equipped with a control device which shall energize a conspicuous visible or audible alarm signal in such a manner that the individual entering the high radiation area and the licensee or a supervisor of the activity are made aware of the entry; or

(iii) Maintained locked except during periods when access to the area is required, with positive control over each individual entry.

(3) The controls required by subparagraph (2) of this paragraph shall be established in such a way that no individual will be prevented from leaving a high radiation area.

(4) In the case of a high radiation area established for a period of 30 days or less, direct surveillance to prevent unauthorized entry may be substituted for the controls required by subparagraph (2) of this paragraph.

35 FR 5033

(5) Any licensee, or applicant for a license, may apply to the Commission for approval of methods not included in subparagraphs (2) and (4) of this paragraph for controlling access to high radiation areas. The Commission will approve the proposed alternatives if the licensee or applicant demonstrates that the alternative methods of control will prevent unauthorized entry into a high radiation area, and that the requirement of subparagraph (3) of this paragraph is met.

42 FR 64618

(6) Each area in which there may exist radiation levels in excess of 500 rems in one hour at one meter from a sealed radio-active source[1] that is used to irradiate materials shall:[2]

(i) Have each entrance or access point equipped with entry control devices which shall function automatically to prevent any individual from inadvertently entering the area when such radiation levels exist; permit deliberate entry into the area only after a control device is actuated that shall cause 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 dose in excess of 100 mrem in one hour; and prevent operation of the source if the source would produce radiation levels in the area that could result in a dose to an individual in excess of 100 mrem in one hour. The entry control devices required by this paragraph (c)(6) shall be established in such a way that no individual will be prevented from leaving the area.

42 FR 64619

(ii) Be equipped with additional control devices such that upon failure of the entry control devices to function as required by paragraph (c)(6)(i) of this section the radiation level within the area, from the sealed source, shall be reduced below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour; and visible and audible alarm signals shall be generated to make an individual attempting to enter the area 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 such failure of the entry control devices.

(iii) Be equipped with control devices such that upon failure or removal of physical radiation barriers other than the source's shielded storage container the radiation level from the source shall be reduced below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour; and visible and audible alarm signals shall be 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. When the shield for the stored source is a liquid, means shall be provided to monitor the integrity of the shield and to signal, automatically, loss of adequate shielding. 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 this paragraph (c)(6)(iii).

42 FR 64619

(iv) Be equipped with devices that will automatically generate 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 shall be installed in the area and which can prevent the source from being put into operation.

(v) Be controlled by use of such administrative procedures* and such devices as are necessary to assure that the area is cleared of personnel prior to each use of the source preceding which use it might have been possible for an individual to have entered the area.

(vi) Be checked by a physical radiation measurement to assure 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 dose in excess of 100 mrem in one hour.

(vii) Have entry control devices required in paragraph (c)(6)(i) of this section which have been tested for proper functioning prior to initial operation with such source of radiation on any day that operations are not uninterruptedly continued from the previous day or before resuming operations after any unintended interruption, and for which records are kept of the dates, times, and results of such tests of func-

*Amended.

[1] This paragraph (c)(6) does not apply to radioactive sources that are used in teletherapy, in 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, is always physically inaccessible to any individual and cannot create high levels of radiation in an area that is accessible to any individual. This paragraph (c)(6) also does not apply to sources from which the radiation is incidental to some other use nor to nuclear reactor generated radiation other than radiation from byproduct, source, or special nuclear materials that are used in sealed sources in non-self-shielded irradiators.

[2] These requirements apply after Mar. 14, 1978. Each person licensed to conduct activities to which this paragraph (c)(6) applies and who is not in compliance with the provisions of this paragraph on Mar. 14, 1978, shall file with the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, on or before June 14, 1978, information describing in detail the actions taken or to be taken to achieve compliance with this paragraph by Dec. 14, 1978, and may continue activities in conformance with present license conditions and the provisions of the previously effective § 20.203 until such compliance is achieved. For such persons compliance must be achieved not later than Dec. 14 1978.

‡Amended 43 FR 2167.

[25 FR 10914]

§ 20.204 Same; exceptions.

Notwithstanding the provisions of § 20.203,

(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 inches from the surface of the source container or housing does not exceed five millirem per hour.

[36 FR 5033]

(b) Rooms or other areas in hospitals are not required to be posted with caution signs, and control of entrance or access thereto pursuant to § 20.203(c) is not required, because of the presence of patients containing byproduct material provided that there are personnel in attendance who will take the precautions necessary to prevent the exposure of any individual to radiation or radioactive material in excess of the limits established in the regulations in this part.

[25 FR 10914]

(c) Caution signs are not required to be posted at areas or rooms containing radioactive materials for periods of less than eight 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 the regulations in this part and; (2) such area or room is subject to the licensee's control.

[36 FR 5033]

(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.

[39 FR 17972]

§ 20.205 Procedures for picking up, receiving, and opening packages.

(a)(1) Each licensee who expects to receive a package containing quantities of radioactive material in excess of the Type A quantities specified in paragraph (b) of this section shall:

(i) If the package is to be delivered to the licensee's facility by the carrier, make arrangements to receive the package when it is offered for delivery by the carrier; or

(ii) If the package is to be picked up by the licensee at the carrier's terminal, make arrangements to receive notification from the carrier of the arrival of the package, at the time of arrival.

(2) Each licensee who picks up a package of radioactive material from a carrier's terminal shall pick up the package expeditiously upon receipt of notification from the carrier of its arrival.

(b)(1) Each licensee, upon receipt of a package of radioactive material, shall monitor the external surfaces of the package for radioactive contamination caused by leakage of the radioactive contents, except:

(i) Packages containing no more than the exempt quantity specified in the table in this paragraph;

(ii) Packages containing no more than 10 millicuries of radioactive material consisting solely of tritium, carbon-14, sulfur-35, or iodine-125;

(iii) Packages containing only radioactive material as gases or in special form;

(iv) Packages containing only radioactive material in other than liquid form (including Mo-99/Tc-99m generators) and not exceeding the Type A quantity limit specified in the table in this paragraph; and

(v) Packages containing only radionuclides with half-lives of less than 30 days and a total quantity of no more than 100 millicuries.

The monitoring shall be performed as soon as practicable after receipt, but no later than three hours after the package is received at the licensee's facility if received during the licensee's normal working hours, or eighteen hours if received after normal working hours.

(2) If removable radioactive contamination in excess of 0.01 microcuries (22,000 disintegrations per minute) per 100 square centimeters of package surface is found on the external surfaces of the package, the licensee shall immediately notify the final delivering carrier and, by telephone and telegraph, mailgram, or facsimile,† the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office shown in Appendix D.

TABLE OF EXEMPT AND TYPE A QUANTITIES

Transport group[1]	Exempt quantity limit (in millicuries)	Type A quantity limit (in curies)
I	.01	0.001
II	0.1	0.050
III	1	3
IV	1	20
V	1	20
VI	1	1000
VII	65,000	1000
Special Form	1	20

[1]The definitions of "transport group" and "special form" are specified in § 71.4 of this chapter.

[39 FR 17972]

(c)(1) Each licensee, upon receipt of a package containing quantities of radioactive material in excess of the Type A quantities specified in paragraph (b) of this section, other than those transported by exclusive use vehicle, shall monitor the radiation levels external to the package. The package shall be monitored as soon as practicable after receipt, but no later than three hours after the package is received at the licensee's facility if received during the licensee's normal working hours, or 18 hours if received after normal working hours.

(2) If radiation levels are found on the external surface of the package in excess of 200 millirem per hour, or at three feet from the external surface of the package in excess of 10 millirem per hour,

[41 FR 16445]

the licensee shall immediately notify by telephone and telegraph, mailgram, or facsimile, the director of the appropriate NRC Regional Office listed in Appendix D, and the final delivering carrier.

[39 FR 17972]

(d) Each licensee shall establish and maintain procedures for safely opening packages in which licensed 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.

[39 FR 22220]

§ 20.206 Instruction of personnel.

Instructions required for individuals working in or frequenting any portion of a restricted area are specified in § 19.12 of this chapter.

†Amended 41 FR 16445.

(c) (1) Records of individual exposure to radiation and to radioactive material which must be maintained pursuant to the provisions of paragraph (a) of this section and records of bioassays, including results of whole body counting examinations, made pursuant to § 20.108, shall be preserved until the Commission authorizes disposition.

(2) Records of the results of surveys and monitoring which must be maintained pursuant to paragraph (b) of this section shall be preserved for two years after completion of the survey except that the following records shall be maintained until the Commission authorizes their disposition: (i) records of the results of surveys to determine compliance with § 20.103(a); (ii) in the absence of personnel monitoring data, records of the results of surveys to determine external radiation dose; and (iii) records of the results of surveys used to evaluate the release of radioactive effluents to the environment.

(3) Records of disposal of licensed material made pursuant to §§ 20.302, 20.303, and deleted § 20.304* are to be maintained until the Commission authorizes their disposition.

(4) Records which must be maintained pursuant to this part may be the original or a reproduced copy or microform if such reproduced copy or microform is duly authenticated by authorized personnel and the microform is capable of producing a clear and legible copy after storage for the period specified by Commission regulations.

(5) If there is a conflict between the Commission's regulations in this part, license condition, or technical specification, or other written Commission approval or authorization pertaining to the retention period for the same type of record, the retention period specified in the regulations in this part for such records shall apply unless the Commission pursuant to § 20.501, has granted a specific exemption from the record retention requirements specified in the regulations in this part.

§ 20.402 Reports of theft or loss of licensed material.

(a) Each licensee shall report by telephone† to the Director of the appropriate Nuclear Regulatory Commission of the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix D, immediately after its occurrence becomes known to the licensee, any loss or theft of licensed material in such quantities and under such circumstances that it appears to the licensee that a substantial hazard may result to persons in unrestricted areas.

(b) Each licensee who is required to make a report pursuant to paragraph (a) of this section shall, within thirty (30) days after he learns of the loss or theft, make a report in writing to the appropriate NRC Regional Office listed in Appendix D with copies to the Director of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, setting forth the following information:

(1) A description of the licensed material involved, including kind, quantity, chemical, and physical form;

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

(3) A statement of disposition or probable disposition of the licensed material involved;

(4) Radiation exposures to individuals, circumstances under which the exposures occurred, and the extent of possible hazard to persons in unrestricted areas;

(5) Actions which have been taken, or will be taken, to recover the material; and

(6) Procedures or measures which have been or will be adopted to prevent a recurrence of the loss or theft of licensed material.

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

(d) Any report filed with the Commission pursuant to this section shall be so prepared that names of individuals who may have received exposure to radiation are stated in a separate part of the report.

§ 20.403 Notifications of incidents.

(a) *Immediate notification.* Each licensee shall immediately notify by telephone and telegraph, mailgram, or facsimile, the Director of the appropriate NRC Regional Office listed in Appendix D of any incident involving byproduct, source, or special nuclear material possessed by him and which may have caused or threatens to cause:

(1) Exposure of the whole body of any individual to 25 rems or more of radiation; exposure of the skin of the whole body of any individual of 150 rems or more of radiation; or exposure of the feet, ankles, hands or forearms of any individual to 375 rems or more of radiation; or

(2) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 5,000 times the limits specified for such materials in Appendix B, Table II; or

(3) A loss of one working week or more of the operation of any facilities affected; or

(4) Damage to property in excess of * $200,000. ‡

(b) *Twenty-four hour notification.* Each licensee shall within 24 hours notify by telephone and telegraph, mailgram, or facsimile, the Director of the appropriate NRC Regional Office listed in Appendix D of any incident involving licensed material possessed by him and which may have caused or threatens to cause:

(1) Exposure of the whole body of any individual to 5 rems or more of radiation; exposure of the skin of the whole body of any individual to 30 rems or more of radiation; or exposure of the feet, ankles, hands, or forearms to 75 rems or more of radiation; or

(2) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 500 times the limits specified for such materials in Appendix B, Table II; or

(3) A loss of one day or more of the operation of any facilities affected; or

(4) Damage to property in excess of $2,000.‡

(c) Any report filed with the Commission pursuant to this section shall be prepared so that names of individuals who have received exposure to radiation will be stated in a separate part of the report.

(d) For nuclear power reactors licensed under § 50.21 or § 50.22, the incidents included in paragraph (a) and paragraph (b) in this section shall in addition be reported pursuant to § 50.72.

†Amended 42 FR 43965.

*Section 20.304 provided for burial of small quantities of licensed materials in soil. Notice of the deletion appears in the Federal Register of October 20, 1980 (45 FR ——).

‡Amended 42 FR 43965.

*Correction

Radionuclide [1]	Quantity in curies
Cesium-137	1
Cobalt-60	1
Gold-198	100
Iodine-131	1
Iridium-192	10
Krypton-85	1,000
Promethium-147	10
Technetium-99m	1,000

[1] The Commission may require, as a license condition, or by rule, regulation or order pursuant to § 20.502, reports from licensees who are licensed to use radionuclides not on this list, in quantities sufficient to cause comparable radiation levels.

(b) When an individual terminates employment with a licensee described in paragraph (a) of this section, or an individual assigned to work in such a licensee's facility but not employed by the licensee, completes the work assignment in the licensee's facility, the licensee shall furnish to the Director of Management and Program Analysis, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, a report of the individual's exposures to radiation and radioactive material, incurred during the period of employment or work assignment in the licensee's facility, containing information recorded by the licensee pursuant to §§ 20.401(a) and 20.108. Such report shall be furnished within 30 days after the exposure of the individual has been determined by the licensee or 90 days after the date of termination of employment or work assignment, whichever is earlier.

43 FR 44827

§ 20.409 Notifications and reports to individuals.

(a) Requirements for notifications and reports to individuals of exposure to radiation or radioactive material are specified in § 19.13 of this chapter.

(b) When a licensee is required pursuant to §§ 20.405 or 20.408 to report to the Commission any exposure of an individual to radiation or radioactive material, the licensee shall also notify the individual. Such notice shall be transmitted at a time not later than the transmittal to the Commission, and shall comply with the provisions of § 19.13(a) of this chapter.

38 FR 22220

Exceptions and Additional Requirements

25 FR 10914

§ 20.501 Applications for exemptions.

The Commission may, upon application by any licensee 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 life or property.

25 FR 10914

§ 20.502 Additional requirements.

The Commission may, by rule, regulation, or order, impose upon any licensee such requirements, in addition to those established in the regulations in this part, as it deems appropriate or necessary to protect health or to minimize danger to life or property.

40 FR 8774

§ 20.601 Violations.

An injunction or other court order may be obtained prohibiting any violation of any provision of the Atomic Energy Act of 1954, as amended, or Title II of the Energy Reorganization Act of 1974, or any regulation or order issued thereunder. A court order may be obtained for the payment of a civil penalty imposed pursuant to section 234 of the Act for violation of section 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Act, or section 206 of the Energy Reorganization Act of 1974, or any rule, regulation, or order issued thereunder, or any term, condition, or limitation of any license issued thereunder, or for any violation for which a license may be revoked under section 186 of the Act. Any person who willfully violates any provision of the Act or any regulation or order issued thereunder may be guilty of a crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law.

APPENDIX A [Reserved]

NOTE.—The reporting and record keeping requirements contained in this part have been approved by the General Accounting Office under B-180225 (R0043), (R0044), and (R0084).

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-18)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Cobalt (27)	Co 57	S	3×10⁻⁶	2×10⁻³	1×10⁻⁷	5×10⁻⁵
		I	2×10⁻⁷	1×10⁻³	6×10⁻⁹	4×10⁻⁵
	Co 58m	S	2×10⁻⁵	8×10⁻³	6×10⁻⁷	3×10⁻⁴
		I	9×10⁻⁷	6×10⁻³	3×10⁻⁷	2×10⁻⁴
	Co 58	S	8×10⁻⁷	4×10⁻³	3×10⁻⁸	1×10⁻⁴
		I	5×10⁻⁸	3×10⁻³	2×10⁻⁹	9×10⁻⁵
	Co 60	S	3×10⁻⁷	1×10⁻³	1×10⁻⁸	5×10⁻⁵
		I	9×10⁻⁹	3×10⁻³	3×10⁻¹⁰	3×10⁻⁵
Copper (29)	Cu 64	S	2×10⁻⁶	1×10⁻³	7×10⁻⁸	3×10⁻⁴
		I	1×10⁻⁶	6×10⁻³	4×10⁻⁹	2×10⁻⁴
Curium (96)	Cm 242	S	1×10⁻¹⁰	7×10⁻⁴	4×10⁻¹²	2×10⁻⁵
		I	2×10⁻¹⁰	7×10⁻⁴	6×10⁻¹²	2×10⁻⁵
	Cm 243	S	6×10⁻¹²	1×10⁻⁴	2×10⁻¹³	3×10⁻⁶
		I	1×10⁻¹⁰	7×10⁻⁴	3×10⁻¹²	2×10⁻⁵
	Cm 244	S	9×10⁻¹²	2×10⁻⁴	3×10⁻¹³	7×10⁻⁶
		I	1×10⁻¹⁰	8×10⁻⁴	3×10⁻¹²	2×10⁻⁵
	Cm 245	S	5×10⁻¹²	1×10⁻⁴	2×10⁻¹³	4×10⁻⁶
		I	1×10⁻¹⁰	8×10⁻⁴	4×10⁻¹²	3×10⁻⁵
	Cm 246	S	5×10⁻¹²	1×10⁻⁴	2×10⁻¹³	4×10⁻⁶
		I	1×10⁻¹⁰	8×10⁻⁴	4×10⁻¹²	3×10⁻⁵
	Cm 247	S	5×10⁻¹²	1×10⁻⁴	2×10⁻¹³	4×10⁻⁶
		I	1×10⁻¹⁰	6×10⁻⁴	4×10⁻¹²	2×10⁻⁵
	Cm 248	S	6×10⁻¹³	1×10⁻⁵	2×10⁻¹⁴	4×10⁻⁷
		I	1×10⁻¹¹	4×10⁻⁵	4×10⁻¹³	1×10⁻⁶
	Cm 249	S	1×10⁻⁵	6×10⁻³	4×10⁻⁷	2×10⁻⁴
		I	1×10⁻⁵	6×10⁻³	4×10⁻⁷	2×10⁻⁴
Dysprosium (66)	Dy 165	S	3×10⁻⁶	1×10⁻³	9×10⁻⁸	4×10⁻⁵
		I	2×10⁻⁶	1×10⁻³	7×10⁻⁸	4×10⁻⁵
	Dy 166	S	2×10⁻⁷	1×10⁻³	8×10⁻⁹	4×10⁻⁵
		I	2×10⁻⁷	1×10⁻³	7×10⁻⁹	4×10⁻⁵
Einsteinium (99)	Es 253	S	8×10⁻¹⁰	7×10⁻⁴	3×10⁻¹¹	2×10⁻⁵
		I	6×10⁻¹⁰	7×10⁻⁴	2×10⁻¹¹	2×10⁻⁵
	Es 254m	S	5×10⁻⁸	5×10⁻⁴	2×10⁻¹⁰	2×10⁻⁵
		I	6×10⁻⁹	5×10⁻⁴	2×10⁻¹⁰	2×10⁻⁵
	Es 254	S	2×10⁻¹¹	4×10⁻⁴	6×10⁻¹³	1×10⁻⁵
		I	1×10⁻¹⁰	4×10⁻⁴	4×10⁻¹²	1×10⁻⁵
	Es 255	S	5×10⁻¹⁰	8×10⁻⁴	2×10⁻¹¹	3×10⁻⁵
		I	4×10⁻¹⁰	8×10⁻⁴	1×10⁻¹¹	3×10⁻⁵
Erbium (68)	Er 169	S	6×10⁻⁷	3×10⁻³	2×10⁻⁸	9×10⁻⁵
		I	4×10⁻⁷	3×10⁻³	1×10⁻⁸	9×10⁻⁵
	Er 171	S	7×10⁻⁷	3×10⁻³	2×10⁻⁸	1×10⁻⁴
		I	6×10⁻⁷	3×10⁻³	2×10⁻⁸	1×10⁻⁴
Europium (63)	Eu 152	S	4×10⁻⁷	2×10⁻³	1×10⁻⁸	6×10⁻⁵
	(T/2 = 9.2 hrs)	I	3×10⁻⁷	2×10⁻³	1×10⁻⁸	6×10⁻⁵
	Eu 152	S	1×10⁻⁶	2×10⁻³	4×10⁻¹⁰	8×10⁻⁵
	(T/2 = 13 yrs)	I	2×10⁻⁶	2×10⁻³	6×10⁻¹⁰	8×10⁻⁵
	Eu 154	S	4×10⁻⁹	6×10⁻⁴	1×10⁻¹⁰	2×10⁻⁵
		I	7×10⁻⁹	6×10⁻⁴	2×10⁻¹⁰	2×10⁻⁵
	Eu 155	S	9×10⁻⁸	6×10⁻³	3×10⁻⁹	2×10⁻⁴
		I	7×10⁻⁸	6×10⁻³	3×10⁻⁹	2×10⁻⁴

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-18)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Fermium (100)	Fm 254	S	6×10⁻⁸	4×10⁻³	2×10⁻⁹	1×10⁻⁴
		I	2×10⁻⁸	4×10⁻³	2×10⁻⁹	1×10⁻⁴
	Fm 255	S	2×10⁻⁷	1×10⁻³	6×10⁻¹⁰	3×10⁻⁵
		I	1×10⁻⁸	1×10⁻³	4×10⁻¹⁰	3×10⁻⁵
	Fm 256	S	3×10⁻⁶	3×10⁻³	1×10⁻¹⁰	9×10⁻⁶
		I	2×10⁻⁶	3×10⁻³	6×10⁻¹¹	9×10⁻⁶
Fluorine (9)	F 18	S	5×10⁻⁶	2×10⁻³	2×10⁻⁷	8×10⁻⁵
		I	3×10⁻⁶	1×10⁻³	9×10⁻⁸	5×10⁻⁵
Gadolinium (64)	Gd 153	S	2×10⁻⁷	6×10⁻³	8×10⁻⁹	2×10⁻⁴
		I	9×10⁻⁸	6×10⁻³	3×10⁻⁹	2×10⁻⁴
	Gd 159	S	5×10⁻⁷	2×10⁻³	2×10⁻⁸	8×10⁻⁵
		I	4×10⁻⁷	2×10⁻³	1×10⁻⁸	8×10⁻⁵
Gallium (31)	Ga 72	S	2×10⁻⁷	1×10⁻³	8×10⁻⁹	4×10⁻⁵
		I	2×10⁻⁷	1×10⁻³	6×10⁻⁹	4×10⁻⁵
Germanium (32)	Ge 71	S	1×10⁻⁵	5×10⁻³	4×10⁻⁷	2×10⁻⁴
		I	6×10⁻⁶	5×10⁻³	2×10⁻⁷	2×10⁻⁴
Gold (79)	Au 196	S	1×10⁻⁶	5×10⁻³	4×10⁻⁸	2×10⁻⁴
		I	6×10⁻⁷	4×10⁻³	2×10⁻⁸	1×10⁻⁴
	Au 198	S	3×10⁻⁷	2×10⁻³	1×10⁻⁸	5×10⁻⁵
		I	2×10⁻⁷	1×10⁻³	8×10⁻⁹	5×10⁻⁵
	Au 199	S	1×10⁻⁶	5×10⁻³	4×10⁻⁸	2×10⁻⁴
		I	8×10⁻⁷	4×10⁻³	3×10⁻⁸	2×10⁻⁴
Hafnium (72)	Hf 181	S	4×10⁻⁶	2×10⁻³	1×10⁻⁸	7×10⁻⁵
		I	7×10⁻⁶	2×10⁻³	3×10⁻⁸	7×10⁻⁵
Holmium (67)	Ho 166	S	2×10⁻⁷	9×10⁻⁴	7×10⁻⁹	3×10⁻⁵
		I	2×10⁻⁷	9×10⁻⁴	6×10⁻⁹	3×10⁻⁵
Hydrogen (1)	H3	S	5×10⁻⁶	1×10⁻¹	2×10⁻⁷	3×10⁻³
		I	5×10⁻⁶	1×10⁻¹	2×10⁻⁷	3×10⁻³
		Sub	2×10⁻⁵		4×10⁻⁷	
Indium (49)	In 113m	S	8×10⁻⁶	4×10⁻³	3×10⁻⁷	1×10⁻⁴
		I	7×10⁻⁶	4×10⁻³	2×10⁻⁷	1×10⁻⁴
	In 114m	S	1×10⁻⁷	5×10⁻⁴	4×10⁻⁹	2×10⁻⁵
		I	2×10⁻⁸	5×10⁻⁴	7×10⁻¹⁰	2×10⁻⁵
	In 115m	S	2×10⁻⁶	1×10⁻³	8×10⁻⁸	4×10⁻⁵
		I	2×10⁻⁶	1×10⁻³	6×10⁻⁸	4×10⁻⁵
	In 115	S	2×10⁻⁷	3×10⁻³	9×10⁻⁹	9×10⁻⁵
		I	3×10⁻⁶	3×10⁻³	1×10⁻⁸	9×10⁻⁵
Iodine (53)	I 125	S	5×10⁻⁹	4×10⁻³	8×10⁻¹¹	2×10⁻⁴
		I	2×10⁻⁷	6×10⁻³	6×10⁻⁹	2×10⁻⁴
	I 126	S	8×10⁻⁹	5×10⁻³	9×10⁻¹¹	3×10⁻⁴
		I	3×10⁻⁷	3×10⁻³	1×10⁻⁸	9×10⁻⁵
	I 129	S	2×10⁻⁹	1×10⁻³	2×10⁻¹¹	6×10⁻⁶
		I	7×10⁻⁸	6×10⁻³	2×10⁻⁹	2×10⁻⁴
	I 131	S	9×10⁻⁹	6×10⁻³	1×10⁻¹⁰	3×10⁻⁵
		I	3×10⁻⁷	2×10⁻³	1×10⁻⁸	6×10⁻⁵
	I 132	S	2×10⁻⁷	2×10⁻³	3×10⁻⁹	8×10⁻⁵
		I	9×10⁻⁷	5×10⁻³	3×10⁻⁸	2×10⁻⁴
	I 133	S	3×10⁻⁸	2×10⁻⁴	4×10⁻¹⁰	1×10⁻⁵
		I	1×10⁻⁷	1×10⁻³	7×10⁻⁹	4×10⁻⁵
	I 134	S	5×10⁻⁷	4×10⁻³	6×10⁻⁹	2×10⁻⁴

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-18)

Element (atomic number)	Isotope [1]	†	Table I, Column 1: Air (μCi/ml)	Table I, Column 2: Water (μCi/ml)	Table II, Column 1: Air (μCi/ml)	Table II, Column 2: Water (μCi/ml)
Plutonium (94)	Pu 242	S	2×10^{-12}	1×10^{-6}	6×10^{-14}	5×10^{-8}
		I	4×10^{-11}	9×10^{-6}	1×10^{-12}	3×10^{-7}
	Pu 243	S	2×10^{-6}	1×10^{-2}	6×10^{-8}	3×10^{-4}
		I	2×10^{-6}	1×10^{-2}	8×10^{-8}	3×10^{-4}
	Pu 244	S	2×10^{-12}	1×10^{-6}	6×10^{-14}	4×10^{-8}
		I	3×10^{-11}	3×10^{-6}	1×10^{-12}	1×10^{-7}
Polonium (84)	Po 210	S	5×10^{-10}	2×10^{-5}	2×10^{-11}	7×10^{-7}
		I	2×10^{-10}	5×10^{-6}	7×10^{-12}	2×10^{-7}
Potassium (19)	K 42	S	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	1×10^{-7}	6×10^{-6}	4×10^{-9}	2×10^{-7}
Praseodymium (59)	Pr 142	S	2×10^{-7}	9×10^{-6}	7×10^{-9}	3×10^{-7}
		I	2×10^{-7}	9×10^{-6}	5×10^{-9}	3×10^{-7}
	Pr 143	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-8}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	5×10^{-8}
Promethium (61)	Pm 147	S	6×10^{-8}	6×10^{-3}	2×10^{-9}	2×10^{-7}
		I	1×10^{-7}	6×10^{-3}	3×10^{-9}	2×10^{-7}
	Pm 149	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-8}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-8}
Protactinium (91)	Pa 230	S	2×10^{-9}	7×10^{-5}	6×10^{-11}	2×10^{-6}
		I	8×10^{-10}	7×10^{-5}	3×10^{-11}	2×10^{-6}
	Pa 231	S	1×10^{-12}	3×10^{-3}	4×10^{-14}	9×10^{-8}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	2×10^{-7}
	Pa 233	S	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-6}
		I	2×10^{-7}	3×10^{-3}	6×10^{-9}	1×10^{-6}
Radium (88)	Ra 223	S	2×10^{-9}	2×10^{-5}	6×10^{-11}	7×10^{-7}
		I	2×10^{-10}	1×10^{-4}	8×10^{-12}	4×10^{-6}
	Ra 224	S	5×10^{-9}	7×10^{-5}	2×10^{-10}	2×10^{-6}
		I	7×10^{-10}	2×10^{-4}	2×10^{-11}	5×10^{-6}
	Ra 226	S	3×10^{-11}	4×10^{-7}	3×10^{-13}	3×10^{-8}
		I	5×10^{-11}	9×10^{-4}	2×10^{-12}	3×10^{-8}
	Ra 228	S	7×10^{-11}	8×10^{-7}	2×10^{-12}	3×10^{-8}
		I	4×10^{-11}	7×10^{-4}	1×10^{-12}	3×10^{-8}
Radon (86)	Rn 220	S	3×10^{-7}		1×10^{-8}	
	Rn 222 [3]	***	3×10^{-8}		3×10^{-9}	
Rhenium (75)	Re 183	S	3×10^{-6}	2×10^{-2}	9×10^{-8}	6×10^{-4}
		I	2×10^{-7}	8×10^{-3}	5×10^{-9}	3×10^{-4}
	Re 186	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Re 187	S	9×10^{-6}	7×10^{-2}	3×10^{-7}	3×10^{-3}
		I	3×10^{-7}	4×10^{-3}	2×10^{-8}	2×10^{-5}
	Re 188	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
Rhodium (45)	Rh 103m	S	8×10^{-5}	4×10^{-1}	3×10^{-6}	1×10^{-2}
		I	6×10^{-5}	3×10^{-1}	2×10^{-6}	1×10^{-2}
	Rh 105	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Rubidium (37)	Rb 86	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	7×10^{-8}	7×10^{-4}	2×10^{-9}	2×10^{-5}
	Rb 87	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	7×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-18)

Element (atomic number)	Isotope [1]	†	Table I, Column 1: Air (μCi/ml)	Table I, Column 2: Water (μCi/ml)	Table II, Column 1: Air (μCi/ml)	Table II, Column 2: Water (μCi/ml)
Ruthenium (44)	Ru 97	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	6×10^{-8}	3×10^{-4}
	Ru 103	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	8×10^{-7}	2×10^{-3}	3×10^{-8}	8×10^{-5}
	Ru 105	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Ru 106	S	8×10^{-8}	4×10^{-4}	3×10^{-9}	1×10^{-5}
		I	6×10^{-8}	3×10^{-4}	2×10^{-9}	1×10^{-5}
Samarium (62)	Sm 147	S	2×10^{-12}	2×10^{-6}	2×10^{-13}	6×10^{-8}
		I	3×10^{-12}	2×10^{-6}	9×10^{-13}	7×10^{-8}
	Sm 151	S	6×10^{-7}	1×10^{-3}	2×10^{-8}	4×10^{-5}
		I	1×10^{-7}	1×10^{-3}	5×10^{-9}	4×10^{-5}
	Sm 153	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Scandium (21)	Sc 46	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
		I	2×10^{-6}	1×10^{-3}	8×10^{-10}	4×10^{-5}
	Sc 47	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
	Sc 48	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
Selenium (34)	Se 75	S	1×10^{-6}	9×10^{-3}	4×10^{-8}	3×10^{-4}
		I	1×10^{-7}	8×10^{-3}	4×10^{-9}	3×10^{-4}
Silicon (14)	Si 31	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
		I	1×10^{-6}	6×10^{-3}	3×10^{-8}	2×10^{-4}
Silver (47)	Ag 105	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	8×10^{-6}	3×10^{-2}	3×10^{-8}	1×10^{-3}
	Ag 110m	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	1×10^{-6}	9×10^{-4}	3×10^{-10}	3×10^{-5}
	Ag 111	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
Sodium (11)	Na 22	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
		I	9×10^{-7}	9×10^{-3}	3×10^{-10}	3×10^{-4}
	Na 24	S	2×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
Strontium (38)	Sr 85m	S	4×10^{-6}	2×10^{-2}	1×10^{-7}	7×10^{-4}
		I	3×10^{-6}	2×10^{-2}	1×10^{-7}	7×10^{-4}
	Sr 85	S	2×10^{-7}	3×10^{-3}	8×10^{-9}	1×10^{-4}
		I	1×10^{-7}	5×10^{-3}	4×10^{-9}	2×10^{-4}
	Sr 89	S	3×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
		I	4×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
	Sr 90	S	1×10^{-9}	1×10^{-4}	3×10^{-11}	3×10^{-6}
		I	5×10^{-9}	1×10^{-4}	2×10^{-10}	4×10^{-6}
	Sr 91	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	3×10^{-7}	1×10^{-3}	9×10^{-9}	5×10^{-5}
	Sr 92	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
Sulfur (16)	S 35	S	3×10^{-7}	2×10^{-3}	9×10^{-9}	6×10^{-5}
		I	3×10^{-7}	8×10^{-3}	9×10^{-9}	3×10^{-4}
Tantalum (73)	Ta 182	S	4×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
		I	2×10^{-8}	1×10^{-3}	7×10^{-10}	4×10^{-5}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Zinc (30)	Zn 65	S	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
		I	6×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
	Zn 69m	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Zn 69	S	7×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-3}
		I	9×10^{-6}	5×10^{-2}	3×10^{-7}	2×10^{-3}
Zirconium (40)	Zr 93	S	1×10^{-7}	2×10^{-3}	4×10^{-9}	8×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Zr 95	S	1×10^{-7}	2×10^{-3}	4×10^{-9}	6×10^{-5}
		I	3×10^{-8}	2×10^{-3}	1×10^{-9}	6×10^{-5}
	Zr 97	S	1×10^{-7}	5×10^{-3}	4×10^{-9}	2×10^{-4}
		I	9×10^{-8}	5×10^{-3}	3×10^{-9}	2×10^{-4}
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.		Sub	1×10^{-6}		3×10^{-8}	
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.			3×10^{-9}	9×10^{-5}	1×10^{-10}	3×10^{-6}
Any single radionuclide not listed above, which decays by alpha emission or spontaneous fission.			6×10^{-11}	4×10^{-7}	2×10^{-11}	3×10^{-8}

[1] These radon concentrations are appropriate for protection from radon-222 combined with its short-lived daughters. Alternatively, the value in Table I may be replaced by one-third (⅓) "working level." (A "working level" is defined as any combination of short-lived radon-222 daughters, polonium-218, lead-214, bismuth-214 and polonium-214, in one liter of air, without regard to the degree of equilibrium, that will result in the ultimate emission of 1.3×10^{5} MeV of alpha particle energy.) The Table II value may be replaced by one-thirtieth (1/30) of a "working level." The limit on radon-222 concentrations in restricted areas may be based on an annual average.

‡4. For soluble mixtures of U-238, U-234 and U-235 in air chemical toxicity may be the limiting factor. If the percent by weight (enrichment) of U-235 is less than 5, the concentration value for a 40-hour workweek, Table I, 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 8×10^{-2} SA μCi-hr/ml, where SA is the specific activity of the uranium inhaled. The concentration value for Table II is 0.007 milligrams uranium per cubic meter of air. The specific activity for natural uranium is 6.77×10^{-7} curies per gram U. The specific activity for other mixtures of U-238, U-235 and U-234, if not known, shall be:

$SA = 3.6 \times 10^{-7}$ curies/gram U (U-depleted $E \geq 0.72$)

$SA = (0.4 + 0.38\,E + 0.0034\,E^2)\ 10^{-6}$

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

*Amended 37 FR 23319.

**Amended 39 FR 23990; footnote redesignated 40 FR 50704.

***Amended 40 FR 50704.

†Amended 38 FR 29314.

‡Amended 39 FR 25461; redesignated 39 FR 50704.

APPENDIX C

Material	Microcuries
Americium-241	.01
Antimony-122	100
Antimony-124	10
Antimony-125	10
Arsenic-73	100
Arsenic-74	10
Arsenic-76	10
Arsenic-77	100
Barium-131	10
Barium-133	10
Barium-140	10
Bismuth-210	1
Bromine-82	10
Cadmium-109	10
Cadmium-115m	10
Cadmium-115	100
Calcium-45	10
Calcium-47	10
Carbon-14	100
Cerium-141	100
Cerium-143	100
Cerium-144	1
Cesium-131	1,000
Cesium-134m	100
Cesium-134	1
Cesium-135	10
Cesium-136	10
Cesium-137	10
Chlorine-36	10
Chlorine-38	10
Chromium-51	1,000
Cobalt-58m	10
Cobalt-58	10
Cobalt-60	1
Copper-64	100
Dysprosium-165	10
Dysprosium-166	100
Erbium-169	100
Erbium-171	100
Europium-152 9.2 h	100
Europium-152 13 yr	1
Europium-154	1
Europium-155	10
Fluorine-18	1,000
Gadolinium-153	10
Gadolinium-159	100
Gallium-72	10
Germanium-71	100
Gold-198	100
Gold-199	100
Hafnium-181	10
Holmium-166	100
Hydrogen-3	1,000
Indium-113m	100
Indium-114m	10
Indium-115m	100
Indium-115	10
Iodine-125	1
Iodine-126	1
Iodine-129	0.1
Iodine-131	1
Iodine-132	10
Iodine-133	1
Iodine-134	10
Iodine-135	10
Iridium-192	10
Iridium-194	100
Iron-55	100
Iron-59	10
Krypton-85	100
Krypton-87	10
Lanthanum-140	10
Lutetium-177	100
Manganese-52	10
Manganese-54	10
Manganese-56	10
Mercury-197m	100
Mercury-197	100
Mercury-203	10
Molybdenum-99	100
Neodymium-147	100
Neodymium-149	100
Nickel-59	100
Nickel-63	10
Nickel-65	100
Niobium-93m	10
Niobium-95	10
Niobium-97	10
Osmium-185	10
Osmium-191m[1]	100
Osmium-191	100
Osmium-193	100
Palladium-103	100
Palladium-109	100
Phosphorus-32	10
Platinum-191	100
Platinum-193m	100
Platinum-193	100
Platinum-197m	100
Platinum-197	100
Plutonium-239	.01
Polonium-210	0.1
Potassium-42	10
Praseodymium-142	100
Praseodymium-143	100
Promethium-147	10
Promethium-149	10
Radium-226	.01
Rhenium-186	100
Rhenium-188	100
Rhodium-103m	100
Rhodium-105	100
Rubidium-86	10
Rubidium-87	10
Ruthenium-97	100
Ruthenium-103	10
Ruthenium-105	10
Ruthenium-106	1
Samarium-151	10
Samarium-153	100
Scandium-46	10
Scandium-47	100
Scandium-48	10
Selenium-75	10
Silicon-31	100
Silver-105	10
Silver-110m	1
Silver-111	100
Sodium-24	10
Strontium-85	10
Strontium-89	1
Strontium-90	0.1
Strontium-91	10
Strontium-92	10
Sulphur-35	100
Tantalum-182	10
Technetium-96	10
Technetium-97m	100
Technetium-97	100
Technetium-99m	100
Technetium-99	10
Tellurium-125m	10
Tellurium-127m	10
Tellurium-127	100
Tellurium-129m	10
Tellurium-129	100
Tellurium-131m	10
Tellurium-132	10
Terbium-160	10
Thallium-200	100
Thallium-201	100
Thallium-202	100
Thallium-204	10
**Thorium (natural)[1]	100
Thulium-170	10
Thulium-171	10
Tin-113	10
Tin-125	10
Tungsten-181	10
Tungsten-185	10
Tungsten-187	100
**Uranium (natural)[2]	100
Uranium-233	.01
Uranium-234- Uranium-235	.01
Vanadium-48	10
Xenon-131m	1,000
Xenon-133	100
Xenon-135	100
Ytterbium-175	100
Yttrium-90	10
Yttrium-91	10
Yttrium-92	100
Yttrium-93	100
Zinc-65	10
Zinc-69m	100
Zinc-69	1,000
Zirconium-93	10
Zirconium-95	10
Zirconium-97	10
Any alpha emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	.01
Any radionuclide other than alpha emitting radionuclides, not listed above or mixtures of beta emitters of unknown composition	.1

[35 FR 6425]

[45 FR 71761]

Note.—For purposes of § 20.303, where there is involved a combination of isotopes in known amounts, the limit for the combination should be derived as follows. Determine, for each isotope in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific isotope when not in combination. The sum of such ratios for all the isotopes in the combination may not exceed "1" (i.e., "unity").

[1] Based on alpha disintegration rate of Th-232, Th-230 and their daughter products.

[2] Based on alpha disintegration rate of U-238, U-234, and U-235.

* Amended 36 FR 16898.

** Amended 39 FR 23990.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
Office of Public Affairs
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FOR IMMEDIATE RELEASE
(Wednesday, October 8, 1980)

NRC CONSIDERS CHANGES TO REGULATIONS ON DISPOSAL OF RADIOACTIVE WASTES RESULTING FROM MEDICAL RESEARCH

The Nuclear Regulatory Commission is considering changing its regulations to eliminate the requirement that licensed biomedical research laboratories and hospitals send animal carcasses and vials containing tracer amounts of certain radioactive materials to radioactive waste burial grounds. Under the amended regulations, licensees would be able to dispose of these materials without regard to their radioactivity.

The licensed materials covered by the changes would be:

1) 0.05 microcuries or less of hydrogen-3 or carbon-14, per gram of liquid scintillation media, and

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

Tracer amounts of hydrogen-3 and carbon-14 are added to chemical compounds or experimental drugs to study the drugs' behavior in research animals. After the drug containing radioactive material is administered to an animal, a sample from the animal's urine, blood or body tissue is combined with an organic solvent--such as toluene--in a small vial to make a "liquid scintillation medium." The vial is placed in a "liquid scintillation counter," which measures the amount of radioactivity in the sample. The radioactivity amount can be used to derive the needed information on the behavior of the drug. The vials are used once and then are ready for disposal.

Research laboratories and hospitals throughout the country are using between 84 and 159 million vials per year, which represents 200 to 400 thousand gallons of liquid scintillation media. Disposal of this waste in radioactive waste burial grounds requires approximately 400 thousand cubic feet of storage space at a cost of over $13 million per year.

INFORMATION REQUIRED FOR COMMISSION APPROVAL OF TREATMENT OR DISPOSAL BY INCINERATION

Revised October 3, 1979

1. State specifically the isotopes you wish to incinerate. For each isotope listed, you should submit calculations demonstrating that air concentrations of the effluents at the stack are in accordance with the requirements of Section 20.106 of 10 CFR Part 20.

2. Submit the characteristics of the incinerator such as height of the stack, height of and distance to buildings in the surrounding areas, rated airflow of the incinerator in cubic feet per hour or similar units and its proximity to any air intake ducts.

3. The gaseous effluent from the incinerator stack should not exceed the limits specified for air in Appendix B, Table II, 10 CFR Part 20, when averaged over a twenty-four (24) hour period.

4. In order to be in compliance with the ALARA philosophy stated in Section 20.1(c) of 10 CFR Part 20, the gaseous effluent from the incinerator stack should be a fraction (approximately 10 percent) of the limits specified for air in Appendix B, Table II, 10 CFR Part 20, when averaged over a one year period.

5. Describe the method of measurement or estimation of the concentration of radioactive material appearing in the ash residue.

6. Describe the procedures for handling and disposing of ash from the incinerator.

7. Describe procedures to be followed to prevent overexposure of personnel during all phases of the operation, including instruction given to personnel handling the combustibles and the ash.

8. Submit evidence that all state and local regulations concerning incineration of radioactive material have been met by your institution.

9. State the maximum number of burns to be performed in any one week and the maximum number of burns per year.

Enclosure 3