[redacted]
Flight and Engine Instrument Division
Bendix Corporation
South Montrose, Pennsylvania

October 14, 1968

Dear [redacted]

Attached for your reference and retention is information on use of tritium for luminous devices:

1. USAEC Notice, June 14, 1960, Radiation Safety Evaluation of Tritium-Activated Dials in Luminous Watches and Clocks.

2. USAEC, IR, March 30, 1962, AEC Establishes Criteria for Installation of Automobile Lock Illuminators Containing Tritium.

3. USAEC, IR, June 30, 1960, AEC to permit Use of Tritium on Luminous Timepieces.

4. Miscellaneous Report, Advantages of Tritium Luminescent Devices, J. W. Hitch.

5. Copy of Title 10, Chapter 1, Part 20 with amendments that indicates Standards for Protection Against Radiation that must be adhered to by all licensees.

6. Copy of Title 10, Part 30, Rules of General Applicability to Licensing of Byproduct Material. This will provide specific information relative to the dials containing tritiated phosphor that you propose to obtain from Conrad Industries for in-plant assembly.

7. Copy of Military Specifications, MIL-T-46343 (ORD) dated May 21, 1962, Tritium (Hydrogen 3) solid form, sealed self luminous sources applicable for military material, general specification for. This is for your reference only as only Title 10, Chapter 1, Part 20, and Title 10, Part 30 will apply to you if a license is required. The Pennsylvania Department of Health may have other requirements that you may want to investigate.

8. Copy of a handling procedure from U. S. Radium, P.O.Box 246 Morristown, New Jersey who make tritiated dials, etc.

We have handled these materials at the Kansas City Division and the following basic requirements were established:

I. Preparation of Tritiated Phosphor

1. Tritiated phosphor and adhesive binder were mixed in an exhausted hood to control airborne and surface contamination.

2. Containers of Tritiated Phosphor mixed or not mixed with adhesive should be labeled, "Radioactive Material." Storage should be in a locked cabinet.

3. A suitable disposable paper should be placed on the working surface under the container of tritiated phosphor and parts prior to painting the material on to dials.

4. Personnel should wear rubber gloves and paper shop coats when applying the adhesive.

5. Personnel should not smoke, eat, or drink while applying the adhesive and shall wash their hands prior to smoking, eating or drinking, and upon termination of work with the adhesive.

6. The disposable paper, gloves, brush, and other contaminated items such as paper shop coats, Kimwipes shall be placed in

a plastic bag and sealed. Contact Health and Safety for disposal.

7. The tritiated phosphor should be overcoated with a suitable transparent sealing material to minimize the possibility of contamination because of rubbing the surface of the tritiated phosphor or phosphor material becoming loose and falling off.

8. Areas where phosphor was mixed or applied were periodically monitored for presence of loose material, and completed dials were periodically evaluated for adequacy of adhesive and seals to contain the tritiated phosphor.

II. Handling of dials subsequent to painting with tritiated phosphor-adhesive material and overcoated with a suitable sealing material such as: ISI Coat, I-SIS Chemical Inc., Stamford, Connecticut or Laminar X500 Clear Resin mixed with 7-C-23 Clear Hardener from Magna Chemicals, Los Angeles, California.

1. There is no significant radiation problem with dials in this condition.

2. In the event the phosphor is removed by accidental chipping, the loose material should be picked up, placed into a plastic bag for disposal via the Health and Safety Department.

3. Personnel should wash their hands upon termination of work with the materials, including finished dials, prior to eating smoking, or drinking.

In that we are not completely familiar with your proposed activity the aforementioned information and attachments may serve as guides. We will attempt to forward any other information on this matter you may request.

Yours truly,

[redacted]
Health and Safety, D/541

[redacted]

AEC

UNITED STATES
ATOMIC ENERGY COMMISSION
Washington 25, D. C.

No. E-100
Tel. HAzelwood 7-7831
Ext. 3446

FOR IMMEDIATE RELEASE
(Friday, March 30, 1962)

AEC ESTABLISHES CRITERIA FOR INSTALLATION OF AUTOMOBILE LOCK ILLUMINATORS CONTAINING TRITIUM

The Atomic Energy Commission has approved an amendment to its regulations to establish criteria for the manufacture and installation of automobile lock illuminators, each containing up to 15 millicuries of radioactive tritium. The amendment also establishes criteria for the import of these lock illuminators.

Beta radiation from tritium acts upon phosphors to provide luminosity. There is no detectable external radiation from the lock illuminator.

The Commission has exempted these lock illuminators from its licensing requirements once the illuminators are installed in automobile locks. Manufacture of the luminescent ring containing tritium and its installation into automobile locks are subject to specific AEC licensing under the criteria being announced today.

The tritium used in the lock illuminator is in the form of paint completely sealed in plastic. There could be no dispersion of the material into the environment without destruction of the plastic ring into which it is incorporated. Since there is no detectable external radiation, the device containing up to 15 millicuries of tritium will not present a radiation hazard provided it is manufactured and installed according to specifications which AEC has established.

The Commission previously published for public comment a proposed amendment to its regulations establishing criteria for manufacture and installation of these lock illuminators. No comments were received. Several changes have been made in the interest of clarification. This amendment to AEC regulations 10 CFR Part 30, "Licensing of Byproduct Material," will be effective 30 days after publication in the Federal Register on March 31.

- 30 -

3/30/62

Internal Memorandum

Bendix Kansas City Division

Kansas City, Missouri

Date November 6, 1968 Letter No.

To Memo for File

From [redacted], D/541

Subject HI-LOW SWITCH PLATES (CF 1831)
(PART #1442078-1) PURCHASED IN ASSEMBLY 1441895-2)

On this date [redacted] D/640 advised the writer that [redacted] U. S. Radium Corporation, Bloomsburg, Pennsylvania stated the subject plates contained approximately 40 milli-curies of tritiated phosphor.

Previous correspondence indicating they contain 40 micro-curies is not correct.

[redacted]
Health and Safety

[redacted]

UNITED STATES RADIUM CORPORATION

Recommendations for Handling and Mixing "Undark" Tritium Luminous Compound.

1. Safe Handling:

Open and handle the Tritium Luminous Compound in well ventilated facilities. If possible, confine handling and mixing in one specific area. Avoid any spilling of the luminous compound in the working area.

2. Mixing:

Place a small quantity of the Luminous Compound in a mixing cup.
Do not mix more than you contemplate using at the time.
Add enough U.S.R.C. 6X Adhesive into mixing cup to wet the compound so that upon stirring a smooth but heavy paste is formed. A satisfactory mix is obtained at a ratio of 70% compound to 30% 6X adhesive.
Add U.S.R.C. 6X Thinner drop by drop with stirring until the compound reaches a consistency for painting with a red sable hair brush.
Judicious use of thinner is recommended.

3. Application:

After painting, air dry at room temperature from one to several hours.
Follow by a 1-½ hour oven bake at a temperature of 180°F.

Exercise sanitary precaution in handling and applying. Hands should be thoroughly cleansed after any operation involving Tritium Luminous Compound. Wearing of rubber surgical-type gloves is recommended.

[redacted] 6/63

TITLE 10 - ATOMIC ENERGY

CHAPTER 1 - ATOMIC ENERGY COMMISSION

Part 20 - STANDARDS FOR PROTECTION AGAINST RADIATION

Miscellaneous Amendments (5-57, 4-59, 1-61)

Statement of considerations. In January 1957, the Commission issued the regulations in this part to establish standards for protection of licensees, their employees and the general public against radiation hazards arising out of the possession or use of special nuclear, source or byproduct material under a license issued by AEC. These regulations, among other things prescribe limitations that govern exposure of personnel to radiation and concentrations of radioactive material concentrations of radioactive material which may be discharged into air or water, disposal of radioactive wastes; and limits on levels of radiation outside of restricted areas.

The standards established in the regulation were based on those published by the National Committee on radiation Protection in Handbook 52, "Maximum Permissible Amounts of Radiosotopes in the Human Body and Maximum Permissible Concentrations in Air and Water," and Handbook 59, "Permissible Dose from External Sources of Ionizing Radiations."

As noted by the Commission in its statement published with Part 20 in the Federal Register (22 F.R. 548, January 29, 1957), "The National Committee on Radiation Protection has under review recommendations to limit cumulative exposures over periods of years. The Commission is giving consideration to appropriate amendments to its regulations to deal with this cumulative exposure problem."

In January 1957, the NCRP issued a preliminary statement containing recommendations with respect to the maximum permissible accumulated dose for occupational radiation exposures, as well as for exposures of the population. These recommendations have since been revised and re-issued as an addendum to National Bureau of Standards Handbook 59, dated April 15, 1958. A complete revision by the NCRP of National Bureau of Standards Handbook 52 on "Maximum Permissible Amounts of Radiosotopes in the Human Body and Maximum Permissible Concentrations in Air and Water" was published in June 1959 in a new NBS Handbook 69. These changes were announced by the National Bureau of Standards on April 28, 1959.

On May 2, 1960, the Commission published in the Federal Register proposed amendments designed to bring the Commissions radiation protection standards into accord with these most recent recommendations by the NCRP. Many comments and suggestions have been received in response to the notice of proposed rule making. They have been taken into consideration in preparation of the amendment set forth below.

On May 13, 1960, the President approved certain recommendations which had been made to him by the Federal Radiation Council for the guidance of agencies in the executive branch of the Government. The numerical values contained therein are substantially the same as the corresponding values recommended by the NCRP in Handbook 59 (revised) and those incorporated in the following amendments.

The limits on exposure to radiation [illegible] established in the following [illegible] concerning the biological effects of exposure to [illegible] from concentrations of radioactive material [illegible] believes that these limits established in [illegible] appropriate regulatory basis for protection of the [illegible] public without imposing undue burdens upon [illegible].

Recommended limits on exposure, [illegible] investigation and upon [illegible] protection, represent a consensus as to the [illegible] appropriate degrees of safety in the situations to which they are to apply. While the numerical values for exposure limits established in this regulation provide a conservative standard of safety the nature of the problem is such that lower exposure limits would be used if considered practical. At the same time, if there were sufficient reason, the use of considerably higher exposure limits in this regulation would not have been considered to result in excessive hazards.

The Commission recognizes that guides and recommendations based upon these considerations cannot be converted into regulations without loss of flexibility in applying the recommendations to individual situations. It is, however, the policy of the Commission to minimize this loss of flexibility both in the formulation of its regulations and in their administration to the greatest extent compatible with the nature of the problem and with good regulatory practice.

Literal application of the NCRP and Federal Radiation Council (FRC) standards to individuals who have had prior occupational exposure to radiation requires a determination of the magnitude of previous exposures. Such a determination in many situations may be extremely and unnecessarily burdensome. Frequently, records of previous exposures will be unavailable or available only at great inconvenience and expense. In many cases previous occupational exposures to sources of ionizing radiation beyond the Commission's jurisdiction will not have been recorded. Hence, in formulating the following amendments it has appeared desirable to permit certain exposure to the low levels of radiation specified in paragraph (a) of 20.101 without regard to previous occupational exposure. The limits established in paragraph (a) of 20.101 would permit occupational exposure to the whole body, gonads and blood-forming organs over a period of a year not exceeding one-third the annual exposure to radiation previously permitted under the existing Part 20 regulations. This rate corresponds also to the average annual exposure which may be accumulated under the NCRP and FRC recommendations. It is believed likely that a good many licensees will prefer to limit the occupational exposure of their employees to this level rather than undertake the burden and expense of determining individual previously accumulated exposures from past records.

In [illegible] case where a licensee desires to take advantage of any additional exposure (beyond that permitted whole body exposure) under the NCRP and FRC recommendations, the licensee may do so pursuant to paragraph (b) of 20.101 of the amendments.

One of the problems considered in connection with the [illegible] concerned persons who for any reason might receive an [illegible] concentrations of radioactive material in excess of the established limits. Such [illegible] would, of course, be contrary to the Commission's regulations and might [illegible] be made the subject of appropriate proceedings against the licensee by the Commission. Mere calculation of the "limits" on exposure might, in some cases, lead to unwarranted removal of the individual from employment involving radiation exposure. [illegible] considerable periods of unemployment. The Commission, however, does not adopt such [illegible]. The additional [illegible] to an individual as the result of higher radiation

exposure within the limits prescribed in the amendments is believed to be sufficiently small that, except in rare situations, removal from employment after an accidental over-exposure would not be warranted. Under the amendments, licensees will be required to notify the individual, as well as the Commission, of any exposure to radiation above the limits established. It should be noted that where an individual receives radiation exposure in excess of the limits prescribed for any calendar period (calendar quarter in the case of exposure to radiation, week in the case of exposure to radioactive material), he must be removed from further exposure during the remainder of the applicable period. The regulations require that in determining the accumulated dose of any individual under paragraph (b) of 20.101, previous over-exposures must be included.

The amendments include a comprehensive revision of the values specified in Appendix B, "Concentrations in Air and Water Above Natural Background." The values specified in those tables are the concentrations to which licensees may expose persons in restricted areas, or which may be released by licensees into the environment, without specific approval from the Commission. With respect to most isotopes listed, the principal differences between the values set forth in the new tables and those contained in Appendix B of the regulation published in January 1957 are a reduction to one-third of the concentrations of those radioisotopes having their principal effect upon the gonads or the whole body (i.e., those as to which the "whole body" or the gonads are considered to be the critical organ) and lowering of others to control the exposure to the gastrointestinal tract to 15 rems per year.

The reductions in the values specified in Appendix B do not modify the basic approach in Part 20 with respect to levels of radiation and concentrations of radioactive materials in unrestricted areas. The sections limit levels of radiation and concentrations of radioactive material which may be created in unrestricted areas by licensees, without special authorization from the AEC, to specified low levels. These levels are believed to be sufficiently low to provide reasonable assurance that individuals in unrestricted areas will not receive a dose to the whole body in any period of one year in excess of 0.5 rem. Procedures are incorporated in those sections, as previously, under which the Commission may authorize licensees in specific cases to create higher levels in unrestricted areas where the circumstances of the particular case are such as to provide reasonable assurance that individuals in the unrestricted areas will not receive a dose to the whole body in any period of one year in excess of 0.5 rem.

Authority is reserved to the Commission in 20.108 to require the furnishing of appropriate bio-assay services where necessary or desirable in order to determine the extent of an individual's exposure to radioactive material.

The amendments do not require licensees to calculate a "combined" exposure for employees who receive occupational exposure to internal as well as external radiation. Knowledge of the relative effects of exposure to internal and external radiation, and means for calculating "combined" exposures, are not sufficiently well developed for this to be a workable procedure. As a practical matter, it would be rare for an individual to receive an organ dose in excess of the limits recommended

by the FRC as a result of "combined" exposure from external and internal sources. In any event, observance of the limits on internal exposure and the limits on external exposure will restrict the dose to any organ to a maximum of two times the value recommended by the Federal Radiation Council.

The amendments require licensees to furnish reports to employees of exposure to radiation and concentrations of radioactive material in excess of the limits specified in the amendments. Licensees are also required to furnish periodic exposure information to employees if requested by them. Forms are incorporated in the regulation for recording of occupational exposures and exposure histories which should be of considerable assistance to licensees in complying with the regulations and to the Commission in its enforcement program.

The adoption of the limits specified in these amendments should not be considered as a departure from the principle that unnecessary exposure to ionizing radiation should be avoided.

The following is a summary of some of the principal differences between the amendment set forth below and the proposed amendment published in May 1959:

(a) The table of neutron flux dose equivalents in paragraph (c), 20.4 has been amended to bring it up-to-date with values specified in NCRP Handbook No. 63.

(b) Criteria for measuring concentrations of radon and its decay products, natural uranium, and natural thorium have been revised (paragraphs (b) and (c) of 20.5).

(c) Paragraph (c) of 20.102 has been substantially revised. As published below, it will require any licensee who proposes to expose an employee to radiation within the limits of the accumulated dose formula specified in 20.101(b) to make reasonable attempts to obtain reports of the employee's previous occupational exposure to radiation. It also specifies the occupational dose which must be assumed for any calendar quarter of occupational exposure to radiation for which the licensee is unable to obtain such reports. The values specified for this prupose, as to periods after the effective date of these amendments, have been lowered from 3 rem (whole body exposure) to 1¼ rem. Corresponding reductions have been made for other parts of the body. The new values are the same as the values to which employees may be exposed without obtaining records of previous exposure.

(d) The provisions in 20.103 applicable to exposure of individuals to concentrations of radioactive material in restricted areas have been modified. The modifications are for the purpose of making it clear that in determining whether individuals are being exposed in restricted areas to concentrations of radioactive material within the limits specified, no credit should be taken for particle size or the use of respirators or similar equipment unless approved by the Commission. A paragraph has been added to this section specifying the kinds of information which should be submitted to the Commission to obtain such approvals.

(e) Reference to body burdens of radioactive material has been deleted from 20.108 and from Appendix B. Control of internal exposure is accomplished in the regulation by limiting the concentrations of radioactive material in air and water to which employees may be exposed. Section 20.108 in the amendments provides that in appropriate, specific cases the Commission may require that bio-assay studies be conducted.

(f) Changes have been made in radiation levels specified in paragraph (a), of 20.202. This paragraph establishes requirements concerning the use of personnel monitoring equipment. The new values are high enough to be susceptible of measurement by personnel monitoring equipment which is in general use. At the same time, they are low enough to assure that any exposure to substantial portions of the permitted dose under the regulations will be recorded.

(g) Section 20.206 has been revised to require that a copy of the regulations in this part, and of operating procedures incorporated as a condition of applicable licenses, be posted or kept available for examination upon request. In addition, 20.206 now requires that employees post conspicuously a new form of poster intended to inform employees of the requirements in this part, their right to request information concerning their exposure to radiation, and similar matters.

(h) Changes have been made in the record keeping requirements (20.401) to eliminate two of the record forms which would have been required under the proposed amendments. The information which would have been required by the deleted forms has been incorporated in a simplified Form AEC-5.1

(i) Clarifying revisions have been made in 20.403 pertaining to reports to the Commission of incidents. This section defines incidents that must be reported to the Commission either immediately or within twenty-four hours. The circumstances under which such reports must be furnished to the Commission under the following amendments have been redefined so as to make them consistent with the revised limits on exposure to radiation established by the amendments.

(j) The provisions of the proposed rules published in May 1959 requiring reports to individuals of exposure to radiation have been simplified and reduced. Section 20.404, requiring reports to employees of exposure to radiation upon termination of employment, is now applicable only if the employee requests such a report. The provisions in 20.406 have been revised to require that employees be notified annually of their exposure to radiation only upon request of the employees. In addition, the provision has been redrafted so as to eliminate the need for licensees to furnish this information to employees in the form of a report or other similar document. Section 20.406 requires that the licensee "advise" the employees of such exposure. Under the provisions, the licensee may furnish the information to the employee in any appropriate way, e.g., orally, or otherwise. Section 20.405 retains, without substantial change, the requirement that if there is an exposure of an individual to radiation or to radioactive material in excess of any limit in the regulations or the applicable license, the exposure must be reported both to the Commission and to the individual exposed.

The Commission will welcome suggestions and comments from interested persons for further changes in these rules. Such comments should be addressed to the Secretary, United States Atomic Energy Commission, Washington 25, D.C., Attention, Director, Division of Licensing and Regulation.

GENERAL PROVISIONS

Sec.

PERMISSIBLE DOSES, LEVELS, AND CONCENTRATIONS

PRECAUTIONARY PROCEDURES

WASTE DISPOSAL

RECORDS, REPORTS, AND NOTIFICATION

EXCEPTIONS AND ADDITIONAL REQUIREMENTS

20.501 Applications for Exemptions
20.502 Additional Requirements

ENFORCEMENT

20.601 Violations

AUTHORITY: SS 20.1 to 20.601 issued under 161 (b), 68 Stat 948, 42USC2201.

GENERAL PROVISIONS

Section 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 Atomic Energy Commission and are issued pursuant to the Atomic Energy Act of 1954 (68 Stat. 919).

(b) The use of radioactive material or other sources of radiation not licensed, by the Commission is not subject to the regulations in this Part. However, it is the purpose of these regulations to control the possession, use, and transfer of licensed material by any licensee in such a manner that exposure to such material and to radiation from such material, when added to exposures to unlicensed radioactive material and to other unlicensed sources of radiation in the possession of the licensee, and to radiation therefrom, does not exceed the standards of radiation protection prescribed in the regulations in this part.

Section 20.2 Scope

The regulations in this part apply to all persons who receive, possess, use or transfer byproduct material, source material, or special nuclear material under a general or specific license issued by the Commission pursuant to the regulations in Part 30, 40 or 70 of this chapter.

Section 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;

(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;

(4) "Calendar quarter" means any period determined according to either of the following subdivisions:

(i) January 1 to March 31, inclusive; April 1 to June 30, inclusive; July 1 to September 30, inclusive; October 1 to December 31, inclusive; or

(ii) The first period in a calendar year of 13 complete, consecutive calendar weeks; the second period in a calendar year of 13 complete, consecutive weeks; the third period in a calendar year of 13 complete, consecutive weeks; the fourth period in a calendar year of 13 complete, consecutive calendar weeks. If at the end of a calendar year there are any days not falling within a complete calendar week of that year, such days shall be included (for purposes of this part) within the last complete calendar week of that year. If at the beginning of any calendar year there are days not falling within a complete calendar week of that year, such days shall be included (for purposes of this part) within the last complete calendar week of the previous year.

No licensee shall change the method observed by him of determining calendar quarters for purposes of this part except at the beginning of a calendar year.

(5) "Commission" means the Atomic Energy Commission or its duly authorized reqpresentatives;

(6) "Government agency" means any executive department, commission, in dependent 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.

(7) "Individual" means any human being.

(8) "Licensed material" means source material, special nuclear material, or byproduct material received, possessed, used, or tranferred under a general or specific license issued by the Commission pursuant to the regulations in this chapter.

(9) "License" means a license issued under the regulations in Part 30, 40 or 70 of this chapter. "Licensee" means the holder of such license.

(10) "Occupational dose" includes exposure of an individual to radiation (i) in a restricted area; or (ii) in the course of employment in which the individual's duties involve exposure to radiation; provided, that "occupational dose" shall not be deemed to include any exposure of an individual to radiation for the purpose of medical diagnosis or medical therapy of such individual.

(11) "Person" means (1) any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, government agency other than the Commission, any State, any foreign government or nation or any political subdivision of any such government or nationa, or other entity; and (2) any legal successor, representative, agent, or agency of the foregoing.

(12) "Radiation" means any or all of the following: alpha rays, beta rays, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other atomic particles; but not sound or radio waves, or visible, infrared, or ultraviolet light.

(13) "Radioactive material" includes any such material whether or not subject to licensing control by the Commission.

(14) "Restricted area" means any area access to which is controlled by the licensee. "Restricted area" shall not include any areas used as residential quarters, although a separate room or rooms in a residential building may be set apart as a restricted area.

(15) "Source material" means any material except special nuclear material, which contains by weight one-twentieth of one percent (0.05%) or more of (1) uranium, (2) thorium, or (3) any combination thereof.

(16) "Special nuclear material" means (1) plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Commission, pursuant to the provisions of section 51 of the Act, determines to be special nuclear material, but does not include source material; or (2) any material artifically enriched by any of the foregoing but does not include source material.

(17) "Unrestricted area" means any area entry into which is not controlled by the licensee, and any area used for residential quarters.

(b) Definitions of certain other words and phrases as used in this Part are set forth in other sections, including:

(1) "Airborne radioactivity area" defined in section 20.203.

(2) "Radiation area" and "high radiation area" defined in section 20.202.

(3) "Personnel monitoring equipment" defined in section 20.202.

(4) "Survey" defined in section 20.201.

(5) Units of measurement of dose (rad, rem) defined in section 20.4.

(6) Units of measurement of radioactivity defined in section 20.5.

Section 20.4 Units of Radiation Dose

(a) "Dose", as used in this Part, is the quantity of radiation absorbed, per unit of mass, by the body or by any portion of 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 below.

(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) above, 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 Energy	Number of neutrons per square centimeter equivalent to a dose of 1 rem (neutrons/cm^2)	Average flux to deliver 100 millirem to 40 hours (neutrons/cm^2 per sec.)
Thermal	970×10^6	670
0.0001	720×10^6	500
0.005	820×10^6	570
0.02	400×10^6	280
0.1	120×10^6	80
0.5	43×10^6	30
1.0	26×10^6	18
2.5	29×10^6	20
5.0	26×10^6	18
7.5	24×10^6	17
10	24×10^6	17
10 to 30	14×10^6	10

(d) For determining exposures to X or gamma rays up to 3 Mev, the dose limits specified in Section 20.101 to 20.104, 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.

Section 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 (c) - 3.7×10^{10} disintegrations per second (dps) - 2.2×10^{12} disintegrations per minute (dpm). A commonly used submultiple of the curie is the microcurie (mc). One mc - 0.000001, c - 3.7×10^4 dps - 2.2×10^6 dpm.

(b) For purposes of the regulations in this part, it may be assumed that the daughter activity concentrations in the following table are equivalent to an air concentration of 10^{-7} microcuries of Radon 222 per milliliter of air in equilibrium with the daughters RaA, RaB, RaC, and RaC′:

Maximum time between collection and measurement (hours)[1]	Alpha-emitting daughter activity collected per milliliter of air.	
	Microcuries/cc	Total alpha disintegrations per minute per cc.
0.5	7.2×10^{-8}	0.16
1	4.5×10^{-8}	0.10
2	1.3×10^{-8}	0.028
3	0.3×10^{-8}	0.0072

[1] The duration of sample collection and the duration of measurement should be sufficiently short compared to the time between collection and measurement, as not to have a statistically significant effect upon the results.

(c) Natural uranium and natural thorium. (1) For purposes of the regulations in this part, one curie of natural uranium (U-natural in Appendix B or C) means the sum of 3.7×10^{10} disintegrations per second from U-238 plus 3.7×10^{10} dis/sec from U-234, plus 9×10^{8} dis/sec from U-235. Also, a curie of natural thorium (thorium-natural in Appendix B or C) means the sum of 3.7×10^{10} dis/sec from Th^{232} plus 3.7×10^{10} dis/sec from Th^{223}.

(2) For the purpose of the regulations in this part, one curie of natural uranium (U-natural in Appendix B or C) is equivalent to 3,000 kilograms, or 6,615 pounds of natural uranium; and one curie of natural thorium (thorium-natural in Appendix B or C) is equivalent to 9,000 kilograms or 19,850 pounds of natural thorium.

Section 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.

Section 20.7 Communications

All communications and reports concerning the regulations in this Part, and applications filed under them, should be addressed to the Atomic Energy Commission, 1901 Constitution Avenue, N. W., Washington 25, D.C., Attention: Division of Civilian Application.

PERMISSIBLE DOSES, LEVELS, AND CONCENTRATIONS

Section 20.101 Exposure of Individuals to Radiation in restricted areas

(a) 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 in the licensee's possession a dose in excess of the limits 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	18-3/4
3. Skin of whole body	7½

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

(1) During any calendar quarter the dose to the whole body from radioactive material and other sources of radiation in the licensee's possession 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 AEC-4,[1] or on a clear and legible record containing all the information required in that form; and has otherwise complied with the requirements of section 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.

Section 20.102 Determination of accumulated dose.

(a) This section contains requirements which must be satisfied by licensees who propose, pursuant to paragraph (b) of section 20.101, to permit individuals in a restricted area to receive exposure to radiation in excess of the limits specified in paragraph (a) of section 20.101.

(b) Before permitting any individual in a restricted area to receive exposure to radiation in excess of the limits specified in paragraph (a) of section 20.101, each licensee shall:

(1) Obtain a certificate on Form AEC-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

(2) Calculate on Form AEC-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 section 20.101(b).

(c) (1) In the preparation of Form AEC-4, or a clear and legible record containing all the information required in that form, the licensee shall make a reasonable effort to obtain reports of the individual's previously accumulated occupational dose. For each period for which the licensee obtains such reports, the licensee shall use the dose shown in the report in preparing the form. In any case where a licensee is unable to obtain reports of the individual's occupational dose for a previous complete calendar quarter, it shall be assumed that the individual has received the occupational dose specified in whichever of the following columns apply:

Part of body	Column 1 Assumed exposure in rems for calendar quarters prior to Jan. 1, 1961	Column 2 Assumed exposure in rems for calendar quarters beginning on or after Jan. 1, 1961
Whole body, gonads, active blood-forming organs, head and trunk, lens of eye.	3-3/4	1¼

(2) The licensee shall retain and preserve records used in preparing Form AEC-4.

If calculation of the individual's accumulated occupational dose for all periods prior to January 1, 1961 yields a result higher than the applicable accumulated dose value for the individual as of that date, as specified in paragraph (b) of section 20.101, the excess may be disregarded.

Section 20.103 Exposure of Individuals to Concentrations of Radioactive Material in Restricted Areas

(a) No licensee shall possess, use or transfer licensed material in such a manner as to cause any individual in a restricted area 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 I, of this part. "Expose" as used in this section means that the individual is present in an airborne concentration. No allowance shall be made for the use of protective clothing or equipment, or particle size, except as authorized by the Commission pursuant to paragraph (c) of this section.

(b) The limits given in Appendix B, Table I, of this part are based upon exposure to the concentrations specified for forty hours in any period of seven consecutive days. In any such period where the number of hours of exposure is less than forty, the limits specified in the table may be increased proportionately. In any such period where the number of hours of exposure is greater than forty, the limits specified in the table shall be decreased proportionately.

(c) (1) Except as authorized by the Commission pursuant to this paragraph, no allowance shall be made for particle size or the use of protective clothing or equipment in determining whether an individual is exposed to an airborne concentration in excess of the limits specified in Appendix B, Table I.

(2) The Commission may authorize a licensee to expose an individual in a restricted area to airborne concentrations in excess of the limits specified in Appendix B, Table I, upon receipt of an application demonstrating that the concentration is composed in whole or in part of particles of such size that such particles are not respirable; and that the individual will not inhale the concentrations in excess of the limits established in Appendix B, Table I. Each application under this subparagraph shall include an analysis of particle sizes in the concentrations; and a description of the methods used in determining the particle sizes.

(3) The Commission may authorize a licensee to expose an individual in a restricted area to airborne concentrations in excess of the limits specified in Appendix B, Table I, upon receipt of an application demonstrating that the individual will wear appropriate protective equipment and that the individual will not inhale, ingest or absorb quantities of radioactive material in excess of those which might otherwise be permitted under this part for employees in restricted areas during a 40-hour week. Each application under this subparagraph shall contain the following information:

(i) A description of the protective equipment to be employed, including the efficiency of the equipment for the material involved;

(ii) Procedures for the fitting, maintenance and cleaning of the protective equipment; and

(iii) Procedures governing the use of the protective equipment, including supervisory procedures and length of time the equipment will be used by the individuals in each work week. The proposed periods for use of the equipment by any individual should not be of such duration as would discourage observance by the individual of the proposed procedures;and

(iv) The average concentrations present in the areas occupied by employees.

Section 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 section 20.101.

(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.

(c) The provisions of paragraph (c) of section 20.103, shall apply to exposures subject to paragraph (b) of this section.

Section 20.105 Permissible Levels of Radiation in Unrestricted Areas.

(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.

Section 20.106 Concentrations in Effluents to Unrestricted Areas

(a) There may be included in any application for a license or for amendment of a license proposed limits upon concentrations of licensed and other radioactive material released into air or water in unrestricted areas as a result of the applicant's proposed activities. Such applications should include information as to anticipated average concentrations and anticipated occupancy times for each unrestricted area involved. The Commission will approve the proposed limits if the applicant demonstrates that it is not likely that any individual will be exposed to concentrations 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 one year.

(b) Except as authorized by the Commission pursuant to Section 20.302 or paragraph (a) of this section, no licensee shall possess, use or transfer licensed material in such a manner as to release into air or water in any unrestricted area any concentration of radioactive material 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 one year.

(c) For purposes of this section, determinations as to the concentrations of radioactive material shall be made with respect to the point where such material leaves the restricted area. Where the radioactive material leaves the restricted area in a stack, tube, pipe, or similar conduit, the determination may be made with respect to the point where the material leaves such conduit.

(d) The provisions of this section do not apply to disposal of radioactive material into sanitary sewerage systems (see Section 20.303).

Section 20.107 Medical Diagnosis, Therapy and Research . Nothing in the regulations in this part shall be interpreted as limiting the intentional exposure of patients to radiation for the purpose of medical diagnosis or medical therapy.

Section 20.108 Orders Requiring Furnishing of Bio-assay Services.

Where necessary or desirable in order to aid in determining the extent of an individual's exposure to concentrations of radioactive material, the Commission may incorporate appropriate provisions in any license, directing the licensee to make available to the individual appropriate bio-assay services and to furnish a copy of the reports of such services to the Commission.

PRECAUTIONARY PROCEDURES

Section 20.201 Surveys

(a) As used in the regulations in this Part, "survey" means an evaluation of the radiation hazards incident to the production, use, release, disposal or presence of radioactive materials or other sources of radiation under a specific set of conditions. When appropriate, such evaluation includes a physical survey of the location of materials and equipment, and measurements of levels of radiation or concentrations of radioactive material present.

(b) Each licensee shall make or cause to be made such surveys as may be necessary for him to comply with the regulations in this Part.

Section 20.202 Personnel Monitoring

(a) Each licensee shall supply appropriate personnel monitoring equipment to, and shall require the use of such equipment by:

(1) Each individual who enters a restricted area under such circumstances that he receives, or is likely to receive, a dose in any calendar quarter in excess of 25 percent of the applicable value specified in paragraph (a) of Section 20.101.

(2) Each individual under 18 years of age who enters a restricted area under such circumstances that he receives, or is likely to receive, a dose in any calendar quarter in excess of 5 percent of the applicable value specified in paragraph (a) of Section 20.101.

(3) Each individual who enters a high radiation area.

(b) As used in this Part,

(1) "personnel monitoring equipment" means devices designed to be worn or carried by an individual for the purpose of measuring the dose received (e.g., film badges, pocket chambers, pocket dosimeters, film rings, etc.);

(2) "radiation area" means any area, accessible to personnel, in which there exists radiation, originating in whole or in part within licensed material, at such levels that a major portion of the body could receive in any one hour a dose in excess of 5 millirem, or in any 5 consecutive days a dose in excess of 100 millirem;

(3) "high radiation area" means any area, accessible to personnel, in which there exists radiation originating in whole or in part within licensed material at such levels that a major portion of the body could receive in any one hour a dose in excess of 100 millirem.

Section 20.203 Caution Signs, Labels, and Signals.

(a) (1) Except as otherwise authorized by the Commission, symbols prescribed by this section shall use the conventional radiation caution colors (magenta or purple on yellow background). The symbol prescribed by this section is the conventional three-bladed design:

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

(2) Each high radiation area shall be equipped with a control device which shall either cause the level of radiation to be reduced below that at which an individual might receive a dose of 100 millirem in one hour upon entry into the area or shall energize a conspicuous visible or audible alarm signal in such a manner that the individual entering and the licensee or a supervisor of the activity are made aware of the entry. In the case of a high radiation area established for a period of 30 days or less, such control device is not required.

* or "DANGER"

(d) airborne Radioactivity Areas

(1) As used in the regulations in this Part, "airborne radioactivity area" means (i) any room, enclosure, or operating area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations in excess of the amounts specified in Appendix "B", Table I, Column 1; or (ii) any room, enclosure, or operating area in which airborne radioactive material composed wholly or partly of licensed material exists in concentrations which, averaged over the number of hours in any week during which individuals are in the area, exceed 25% of the amounts specified in Appendix "B", Table I, Column 1.

(2) Each airborne radioactivity area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION*
AIRBORNE RADIOACTIVITY AREA

(e) Additional Requirements

(1) Each area or room in which licensed material is used or stored and which contains any radioactive material (other than natural uranium or thorium) in an amonnt exceeding 10 times the quantity of such material specified in Appendix "C" shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION*
RADIOACTIVE MATERIAL(S)

(2) Each area or room in which natural uranium or thorium is used or stored in an amount exceeding one-hundred times the quantity specified in Appendix "C" shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION*
RADIOACTIVE MATERIAL(S)

(f) Containers

(1) Each container in which is transported, stored, or used a quantity of any licensed material (other than natural uranium or thorium) greater than the quantity of such material specified in Appendix "C" shall bear a durable, clearly visible label bearing the radiation caution symbol and the words:

---

* or "DANGER"

CAUTION*
RADIOACTIVE MATERIAL

(2) Each container in which natural uranium or thorium is transported, stored, or used in a quantity greater than ten times the quantity specified in Appendix "C" shall bear a duralle, clearly visible label bearing the radiation caution symbol and the words:

CAUTION*
RADIOACTIVE MATERIAL

(3) Notwithstanding the provisions of subparagraphs (1) and (2) a label shall not be required:

(i) if the concentration of the material in the container does not exceed that specified in Appendix "B", Table I, Column 2, or

(ii) for laboratory containers, such as beakers, flasks, and test tubes, used transiently in laboratory procedures, when the user is present.

(4) Where containers are used for storage, the labels required in this paragraph shall state also the quantities and kinds of radioactive materials in the containers and the date of measurement of the quantities.

Section 20.204 Exceptions from Posting Requirements.

Notwithstanding the provisions of Section 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.

(b) Rooms or other areas in hospitals are not required to be posted with caution signs because of the presence of patients containing byproduct material provided that there are personnel in attendance who shall 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.

(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.

---

* or "DANGER"

Section 20.205 Exemptions for Radioactive Materials Packaged for Shipment

Radioactive materials packaged and labeled in accordance with regulations of the Interstate Commerce Commission shall be exempt from the labeling and posting requirements of section 20.203 during shipment, provided that the inside containers are labeled in accordance with the provisions of Section 20.203 (f).

Section 20.206 Instruction of personnel; posting of notices to employees.

(a) All individuals working in or frequenting any portion of a restricted area shall be informed of the occurrence of radioactive materials or of radiation in such portions of the restricted area; shall be instructed in the safety problems associated with exposure to such materials or radiation and in precautions or procedures to minimize exposure; shall be instructed in the applicable provisions of Commission regulations and licenses for the protection of personnel from exposures to radiation or radioactive materials; and shall be advised of reports of radiation exposure which employees may request pursuant to these regulations.

(b) Each licensee shall post a current copy of the regulations in this part, a copy of the license, and a copy of operating procedures applicable to work under the license conspicuously in a sufficient number of places in every establishment where employees are employed in activities licensed by the Commission to permit them to observe such documents on the way to or from their place of employment or shall keep such documents available for employee's examination upon request.

(c) Form AEC-3[1] "Notice to Employees", shall be conspicuously posted in a sufficient number of places in every establishment where employees are employed in activities licensed by the Commission to permit them to observe a copy on the way to or from their place of employment.

NOTE: Copies of Form AEC-3 "Notice to Employees", may be obtained by writing to the Manager, appropriate AEC Operations Office or the Director, Division of Licensing and Regulation, Washington 25, D.C.

Section 20.207 Storage of Licensed Material

Licensed materials stored in an unrestricted area shall be secured against unauthorized removal from the place of storage.

WASTE DISPOSAL

Section 20.301 General Requirement

No license shall dispose of licensed material except:

(1) By transfer to an authorized recipient as provided in the regulations in Part 30 40 or 70, whichever may be applicable; or

(2) As authorized pursuant to Section 20.302; or

(3) As provided in Section 20.303 or 20.304, applicable respectively to the disposal of licensed material by release into sanitary sewerage system or burial in soil, or in Section 20.105 (Concentrations in Effluents to Unrestricted Areas).

Section 20.302 Method For Obtaining Approval of Proposed Disposal Procedures

Any licensee or applicant for a license may apply to the Commission for approval of proposed procedures to dispose of licensed material in a manner not otherwise authorized in the regulations in this chapter. Each application should include a description of the licensed material any other radioactive material involved, including the quantities and kinds of such material and levels of radioactivity involved, and the proposed manner and conditions of disposal. The application should also include an analysis and evaluation of pertinent information as to the nature of the environment, including topographical, geological, meteorological, and hydrological characteristics; usage of ground and surface waters in the general area; the nature and location of other potentially affected facilities; and procedures to be observed to minimize the risk of unexpected or hazardous exposures.

Section 20.303 Disposal by Release into Sanitary Sewerage Systems

No licensee shall discharge licensed material into a sanitary sewerage system unless:

(a) It is readily soluble or dispersible in water; and

(b) The quantity of any licensed or other radioactive material released into the system by the licensee in any one day does not exceed the larger of (1) or (2) following:

(1) The quantity which, if diluted by the average daily quantity of sewage released into the sewer by the licensee, will result in an average concentration equal to the limits specified in Appendix "B", Table I, Column I; or

(2) Ten times the quantity of such material specified in Appendix "C"; and

(c) The quantity of any licensed or other radioactive material released in any one month, if diluted by the average monthly quantity of water released by the licensee, will not result in an average concentration exceeding the limits specified in Appendix "B", Table I, Column I; and

(d) The gross quantity of licensed and other radioactive material released into the sewerage system by the licensee does not exceed one curie per year.

Excreta from individuals undergoing medical diagnosis or therapy with radioactive material shall be exempt from any limitations contained in this section.

Section 20.304 Disposal by Burial in Soil

No licensee shall dispose of licensed material by burial in soil unless:

(a) The total quantity of licensed and other radioactive materials buried at any one location and times does not exceed, at the time of burial, 1,000 times the amount specified in Appendix "C", and

(b) Burial is at a minimum depth of four feet; and

(c) Successive burials are separated by distances of at least six feet and not more than 12 burials are made in any year.

RECORDS, REPORTS, AND NOTIFICATION

Section 20.401 Records of Surveys, Radiation Monitoring, and Disposal

(a) Each licensee shall maintain records showing the radiation exposures of all individuals for whom personnel monitoring is required under section 20.202 of the regulations in this part. Such records shall be kept on Form AEC-5,[1] in accordance with the instructions contained in that form or on clear and legible records containing all the information by Form AEC-5. The doses entered on the forms or records shall be for periods of time not exceeding one calendar quarter.

(b) Records of individual radiation exposure which must be maintained pursuant to the provisions of this subsection shall be preserved until December 31, 1964 or until a date five years after termination of the individual's employment, whichever is later. Records which must be maintained pursuant to this part may be maintained in the form of microfilms.

NOTE: Prior to December 31, 1965 the Commission may amend this paragraph to assure the further preservation of records which it determines should not be destroyed.

Section 20.402 Reports of Theft or Loss of Licensed Material

Each licensee shall report by telephone and telegraph to the Manager of the nearest Atomic Energy Commission Operations 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.

Section 20.403 Notifications of Incidents.

(a) Immediate notification. Each licensee shall immediately notify the Manager of the appropriate Atomic Energy Commission Operations Office shown in Appendix "D" by telephone and telegraph 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 III; 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 $100,000.

(b) Twenty-four hour notification. Each licensee shall within 24 hours notify the Manager of the appropriate Atomic Energy Commission Operations Office listed in Appendix D by telephone and telegraph 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 $1,000.

(c) Thirty-day reports. Each licensee shall make a report in writing within 30 days to the Director, Division of Civilian Application, United States Atomic Energy Commission, Washington 25, D.C., of each incident involving licensed material possessed by him which appears to have resulted in the exposure of an individual to radiation or to

concentrations of radioactive material, or to have resulted in levels of radiation or concentrations of radioactive material, in excess of any applicable limits set forth in these regulations or in the licensee's license. Each report required under this paragraph shall describe the nature of the incident, the extent of exposure of persons to radiation or to radioactive material, the levels of radiation and concentrations of radioactive material involved, the cause of the incident, and corrective steps taken or planned to assure against a recurrence of the incident. A copy of each report shall be transmitted to the Manager of the nearest Atomic Energy Commission Operations Office listed in Appendix "D".

(d) Reports to affected individuals. In any case where a licensee is required pursuant to the provisions of this section to report to the Commission any exposure or possible exposure of an individual to radiation or to radioactive material, the licensee shall also notify such individual of the nature and extent of the exposure or possible exposure; and the period of time involved. Such notice shall be in writing and shall contain the following statement in conspicuous letters;

> "This notice to you is required by the Atomic Energy Commission regulations entitled, "Standards for Protection Against Radiation" (10 CFR Part 20). You should preserve this notice with your important papers."

The notice shall be delivered to the individual personally and receipt obtained or shall be delivered by certified mail or registered mail.

Section 20.404 Report to Former Employees of Exposure to Radiation

(a) At the request of a former employee each licensee shall furnish to the former employee a report of the former employee's exposure to radiation as shown in records maintained by the licensee pursuant to section 20.401(a). Such report shall be furnished within 30 days from the time the request is made; shall cover each calendar quarter of the individual's employment involving exposure to radiation, or such lesser period as may be requested by the employee. The report shall also include the results of any calculations and analyses of radioactive material deposited in the body of the employee and made pursuant to the provisions of section 20.108. The report shall be in writing and contain the following statement:

> "This report is furnished to you under the provisions of the Atomic Energy Commission regulations entitled "Standards for Protection Against Radiation" (10 CFR Part 20). You should preserve this report for future reference."

(b) The former employee's request should include appropriate identifying data, such as social security number and dates and locations of employment.

Section 20.405 Reports of Overexposures and excessive Levels and Concentrations.

(a) In addition to any notification required by section 20.403, each licensee shall make a report in writing within 30 days to the Director, Division of Licensing and Regulation, U. S. Atomic Energy Commission, Washington 25, D.C., of (1) each exposure of an individual to radiation or concentrations of radioactive material in excess of any applicable limit in this part or in the licensee's license; (2) any incident for which notification is required by section 20.403; and (3) levels of radiation or

concentrations of radioactive material (not involving excessive exposure of any individual) in an unrestricted area in excess of ten times any applicable limit set forth in this part or in the licensee's license. Each report required under this paragraph shall describe the extent of exposure of persons to radiation or to radioactive material; levels of radiation and concentrations of radioactive material involved; the cause of the exposure, levels or concentrations; and corrective steps taken or planned to assure against a recurrence. The licensee shall transmit a copy of each report to the Manager of the appropriate Atomic Energy Commission Operations Office listed in Appendix D.

(b) In any case where a licensee is required pursuant to the provisions of this section to report to the Commission any exposure of an individual to radiation or to concentrations of radioactive material, the licensee shall also notify such individual of the nature and extent of exposure. Such notice shall be in writing and shall contain the following statement:

> "This report is furnished to you under the provisions of the Atomic Energy Commission regulations entitled "Standards for Protection Against Radiation" (10 CFR Part 20). You should preserve this report for future reference."

Section 20.406 Notice to Employees of Exposure to Radiation

At the request of any employee, each licensee shall advise such employee annually of the employee's exposure to radiation as shown in records maintained by the licensee pursuant to section 20.401(a).

> NOTE: The record keeping and reporting requirements contained herein have been approved by the Bureau of the Budget in accordance with the Federal Reports Act of 1942.

EXCEPTIONS AND ADDITIONAL REQUIREMENTS

Section 20.501 Applications for Exemptions

The Commission may, upon application by and 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.

Section 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 seems appropriate or necessary to protect health or to minimize danger to life or property.

ENFORCEMENT

Section 20.601 Violations

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 crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law.

APPENDIX B

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND

(See last column of table)

Element (atomic number)	Isotope		Table I		Table II	
			Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)	Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
Actinium (89)	Ac 227	S	2X10⁻¹²	6X10⁻⁸	3X10⁻¹⁴	2X10⁻⁹
	Ac 228	I	3X10⁻⁹	9X10⁻⁶	9X10⁻¹¹	3X10⁻⁷
Americium (95)	Am 241	S	2X10⁻¹²	3X10⁻⁸	3X10⁻¹⁴	1X10⁻⁹
	Am 242m	S	6X10⁻¹²	2X10⁻⁸	6X10⁻¹⁴	9X10⁻¹⁰
	Am 243	S	6X10⁻¹²	2X10⁻⁸	2X10⁻¹³	9X10⁻¹⁰
Antimony (51)	Sb 122	S	1X10⁻⁶	3X10⁻⁴	2X10⁻¹¹	1X10⁻⁶
	Sb 124	S	1X10⁻⁷	3X10⁻⁵	2X10⁻¹²	1X10⁻⁷
	Sb 125	S	2X10⁻⁷	7X10⁻⁵	4X10⁻¹²	2X10⁻⁷
Argon (18)	A 37	Sub	8X10⁻⁶	3X10⁻⁴	2X10⁻⁷	1X10⁻³
	A 41	Sub	2X10⁻⁶	7X10⁻⁴	4X10⁻⁸	2X10⁻³
Arsenic (33)	As 73	S	2X10⁻⁶	1X10⁻³	1X10⁻⁷	3X10⁻⁴
	As 74	S	4X10⁻⁷	1X10⁻⁴	1X10⁻⁸	5X10⁻⁵
	As 76	S	3X10⁻⁷	1X10⁻⁴	1X10⁻⁸	3X10⁻⁵
	As 77	S	1X10⁻⁶	4X10⁻⁴	4X10⁻⁸	1X10⁻⁴
Astatine (85)	At 211	S	4X10⁻⁷	2X10⁻³	1X10⁻⁸	8X10⁻⁵
Barium (56)	Ba 131	S	3X10⁻⁷	2X10⁻⁴	2X10⁻¹⁰	1X10⁻⁵
	Ba 140	S	1X10⁻⁷	5X10⁻⁵	4X10⁻⁹	2X10⁻⁶
Berkelium (97)	Bk 249	S	4X10⁻¹	1X10⁻⁶	1X10⁻¹¹	4X10⁻⁸
Beryllium (4)	Be 7	S	6X10⁻⁶	2X10⁻³	2X10⁻⁷	8X10⁻⁵
Bismuth (83)	Bi 205	S	1X10⁻⁶	5X10⁻⁴	4X10⁻⁸	2X10⁻⁵
	Bi 206	S	2X10⁻⁷	1X10⁻⁴	6X10⁻⁹	4X10⁻⁶
	Bi 207	S	3X10⁻⁷	1X10⁻⁴	1X10⁻⁸	4X10⁻⁶
	Bi 210	S	6X10⁻⁸	2X10⁻⁵	2X10⁻⁹	6X10⁻⁷
	Bi 212	S	6X10⁻⁷	2X10⁻⁴	2X10⁻⁸	8X10⁻⁶
Bromine (35)	Br 82	S	4X10⁻⁷	2X10⁻⁴	1X10⁻⁸	6X10⁻⁵
Cadmium (48)	Cd 109	S	3X10⁻⁸	1X10⁻⁵	1X10⁻⁹	4X10⁻⁷
	Cd 115m	S	7X10⁻⁸	2X10⁻⁵	2X10⁻⁹	8X10⁻⁷
	Cd 115	S	4X10⁻⁷	1X10⁻⁴	1X10⁻⁸	4X10⁻⁶
Calcium (20)	Ca 45	S	2X10⁻⁷	1X10⁻⁴	5X10⁻⁹	2X10⁻⁶
	Ca 47	S	3X10⁻⁷	1X10⁻⁴	1X10⁻⁸	4X10⁻⁶
Californium (98)	Cf 249	S	2X10⁻¹²	9X10⁻⁹	6X10⁻¹⁴	3X10⁻¹⁰
	Cf 250	S	5X10⁻¹²	2X10⁻⁸	2X10⁻¹³	6X10⁻¹⁰
	Cf 252	S	2X10⁻¹²	7X10⁻⁹	6X10⁻¹⁴	2X10⁻¹⁰
	Cf 253	S	2X10⁻¹⁰	7X10⁻⁷	6X10⁻¹²	2X10⁻⁸
Carbon (6)	C 14 (CO_2)	Sub	6X10⁻⁶	2X10⁻³	1X10⁻⁷	8X10⁻⁵
Cerium (58)	Ce 141	S	1X10⁻⁶	5X10⁻⁴	3X10⁻⁸	2X10⁻⁵
	Ce 143	S	1X10⁻⁶	4X10⁻⁴	3X10⁻⁸	1X10⁻⁵
	Ce 144	S	6X10⁻⁸	2X10⁻⁵	2X10⁻⁹	6X10⁻⁷

See footnotes at end of table.

Appendix B

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—continued

[See footnotes at end of table.]

Element (atomic number)	Isotope		Table I		Table II	
			Column 1 Air (μc/ml)	Column 2 Water (μc/ml)	Column 1 Air (μc/ml)	Column 2 Water (μc/ml)
Cesium (55)	Cs 131	S	1X10⁻⁶	7X10⁻⁶	4X10⁻⁷	2X10⁻⁶
	Cs 134m	I	3X10⁻⁶	3X10⁻⁶	1X10⁻⁷	9X10⁻⁷
	Cs 134	S	4X10⁻¹¹	2X10⁻⁶	1X10⁻⁸	6X10⁻⁷
	Cs 135	I	6X10⁻⁶	3X10⁻⁶	2X10⁻⁶	1X10⁻⁶
	Cs 135	S	4X10⁻⁶	2X10⁻⁶	1X10⁻⁶	6X10⁻⁷
	Cs 136	I	1X10⁻⁶	1X10⁻⁶	4X10⁻⁸	4X10⁻⁷
	Cs 137	S	6X10⁻⁶	3X10⁻⁶	2X10⁻⁶	1X10⁻⁶
	Cs 137	I	9X10⁻⁶	7X10⁻⁶	3X10⁻⁶	2X10⁻⁶
	Cs 138	I	4X10⁻⁶	2X10⁻⁶	1X10⁻⁶	9X10⁻⁷
	Cs 138	S	3X10⁻⁶	2X10⁻⁶	9X10⁻⁷	6X10⁻⁷
	Ba 137	S	6X10⁻⁶	4X10⁻⁶	2X10⁻⁶	2X10⁻⁶
	Ba 137	I	1X10⁻⁶	8X10⁻⁶	5X10⁻⁷	4X10⁻⁶
Cerium (58)	Ce 141	S	4X10⁻⁶	2X10⁻⁶	1X10⁻⁶	8X10⁻⁷
	Ce 141	I	2X10⁻⁶	2X10⁻⁶	8X10⁻⁷	6X10⁻⁷
	Ce 143	S	3X10⁻⁶	1X10⁻⁶	9X10⁻⁷	4X10⁻⁶
	Ce 143	I	2X10⁻⁶	1X10⁻⁶	7X10⁻⁷	4X10⁻⁶
Chromium (24)	Cr 51	S	1X10⁻⁶	8X10⁻⁶	4X10⁻⁶	3X10⁻⁶
	Cr 51	I	2X10⁻⁶	6X10⁻⁶	8X10⁻⁶	2X10⁻⁶
Cobalt (27)	Co 57	S	3X10⁻⁶	2X10⁻⁶	1X10⁻⁶	8X10⁻⁶
	Co 57	I	2X10⁻⁶	1X10⁻⁶	8X10⁻⁶	4X10⁻⁶
	Co 58m	S	2X10⁻⁶	8X10⁻⁶	6X10⁻⁶	3X10⁻⁶
	Co 58m	I	9X10⁻⁶	6X10⁻⁶	3X10⁻⁶	2X10⁻⁶
	Co 58	S	8X10⁻⁶	6X10⁻⁶	3X10⁻⁶	1X10⁻⁶
	Co 58	I	4X10⁻⁶	3X10⁻⁶	2X10⁻⁶	1X10⁻⁶
	Co 60	S	3X10⁻⁶	1X10⁻⁶	1X10⁻⁶	5X10⁻⁷
	Co 60	I	9X10⁻⁶	1X10⁻⁶	3X10⁻⁶	3X10⁻⁶
Copper (29)	Cu 61	S	2X10⁻⁶	1X10⁻⁶	7X10⁻⁷	3X10⁻⁶
	Cu 61	I	1X10⁻⁶	6X10⁻⁶	4X10⁻⁶	2X10⁻⁶
Curium (96)	Cm 242	S	1X10⁻¹¹	7X10⁻⁶	4X10⁻¹²	2X10⁻⁶
	Cm 242	I	2X10⁻¹¹	1X10⁻⁶	6X10⁻¹²	3X10⁻⁶
	Cm 243	S	6X10⁻¹²	1X10⁻⁶	2X10⁻¹²	8X10⁻⁷
	Cm 243	I	1X10⁻¹¹	2X10⁻⁶	5X10⁻¹²	2X10⁻⁶
	Cm 244	S	9X10⁻¹²	2X10⁻⁶	3X10⁻¹²	2X10⁻⁶
	Cm 244	I	1X10⁻¹¹	8X10⁻⁶	3X10⁻¹²	3X10⁻⁶
	Cm 245	S	8X10⁻¹²	1X10⁻⁶	2X10⁻¹²	8X10⁻⁷
	Cm 245	I	1X10⁻¹¹	8X10⁻⁶	3X10⁻¹²	3X10⁻⁶
	Cm 246	S	8X10⁻¹²	1X10⁻⁶	2X10⁻¹²	8X10⁻⁷
	Cm 246	I	1X10⁻¹¹	8X10⁻⁶	4X10⁻¹²	3X10⁻⁶
Dysprosium (66)	Dy 165	S	8X10⁻⁶	3X10⁻⁶	3X10⁻⁶	1X10⁻⁶
	Dy 165	I	2X10⁻⁶	1X10⁻⁶	7X10⁻⁷	4X10⁻⁶
	Dy 166	S	2X10⁻⁶	1X10⁻⁶	8X10⁻⁷	4X10⁻⁶
	Dy 166	I	3X10⁻⁶	1X10⁻⁶	7X10⁻⁷	4X10⁻⁶
Erbium (68)	Er 169	S	6X10⁻⁶	3X10⁻⁶	2X10⁻⁶	9X10⁻⁷
	Er 169	I	4X10⁻⁶	3X10⁻⁶	1X10⁻⁶	8X10⁻⁷
	Er 171	S	7X10⁻⁶	3X10⁻⁶	2X10⁻⁶	1X10⁻⁶
	Er 171	I	6X10⁻⁶	3X10⁻⁶	2X10⁻⁶	1X10⁻⁶
Europium (63)	Eu 152 (T½=9.2 hrs)	S	4X10⁻⁶	2X10⁻⁶	1X10⁻⁶	6X10⁻⁷
	Eu 152 (T½=13 yrs)	S	1X10⁻⁶	9X10⁻⁷	4X10⁻⁷	3X10⁻⁷
	Eu 154	S	3X10⁻⁶	2X10⁻⁶	8X10⁻⁷	6X10⁻⁷
	Eu 154	I	4X10⁻⁶	6X10⁻⁶	1X10⁻⁶	2X10⁻⁶
	Eu 155	S	9X10⁻⁶	6X10⁻⁶	3X10⁻⁶	2X10⁻⁶
	Eu 155	I	1X10⁻⁶	8X10⁻⁶	4X10⁻⁷	3X10⁻⁶
Fluorine (9)	F 18	S	8X10⁻⁶	3X10⁻⁶	3X10⁻⁶	1X10⁻⁶
	F 18	I	3X10⁻⁶	1X10⁻⁶	9X10⁻⁷	4X10⁻⁷
Gadolinium (64)	Gd 153	S	2X10⁻⁶	6X10⁻⁶	6X10⁻⁷	2X10⁻⁶
	Gd 153	I	9X10⁻⁶	6X10⁻⁶	3X10⁻⁶	2X10⁻⁶
	Gd 159	S	3X10⁻⁶	2X10⁻⁶	1X10⁻⁶	8X10⁻⁷
	Gd 159	I	2X10⁻⁶	1X10⁻⁶	6X10⁻⁷	4X10⁻⁶
Gallium (31)	Ga 72	S	2X10⁻⁶	1X10⁻⁶	6X10⁻⁷	4X10⁻⁶
	Ga 72	I	2X10⁻⁶	1X10⁻⁶	6X10⁻⁷	4X10⁻⁶
Germanium (32)	Ge 71	S	1X10⁻⁶	6X10⁻⁶	4X10⁻⁶	2X10⁻⁶
	Ge 71	I	6X10⁻⁶	4X10⁻⁶	2X10⁻⁶	1X10⁻⁶
Gold (79)	Au 198	S	2X10⁻⁶	8X10⁻⁶	6X10⁻⁷	3X10⁻⁶
	Au 198	I	1X10⁻⁶	6X10⁻⁶	4X10⁻⁷	2X10⁻⁶
	Au 199	S	3X10⁻⁶	2X10⁻⁶	1X10⁻⁶	8X10⁻⁷
	Au 199	I	2X10⁻⁶	1X10⁻⁶	6X10⁻⁷	4X10⁻⁶

Appendix B

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—continued

[See footnotes at end of table.]

Element (atomic number)	Isotope		Table I		Table II	
			Column 1 Air (μc/ml)	Column 2 Water (μc/ml)	Column 1 Air (μc/ml)	Column 2 Water (μc/ml)
Gold (79)	Au 199	S	1X10⁻⁶	6X10⁻⁶	4X10⁻⁷	2X10⁻⁶
	Au 199	I	8X10⁻⁷	6X10⁻⁶	3X10⁻⁷	2X10⁻⁶
Hafnium (72)	Hf 181	S	4X10⁻⁶	2X10⁻⁶	1X10⁻⁶	7X10⁻⁷
	Hf 181	I	3X10⁻⁶	2X10⁻⁶	1X10⁻⁶	6X10⁻⁷
Holmium (67)	Ho 166	S	3X10⁻⁶	2X10⁻⁶	1X10⁻⁶	6X10⁻⁷
	Ho 166	I	2X10⁻⁶	1X10⁻⁶	6X10⁻⁷	4X10⁻⁷
Hydrogen (1)	H 3	S	8X10⁻⁶	1X10⁻⁶	2X10⁻⁶	3X10⁻⁶
	H 3	Sub	2X10⁻⁶		4X10⁻⁶	
Indium (49)	In 113m	S	8X10⁻⁶	4X10⁻⁶	2X10⁻⁶	1X10⁻⁶
	In 113m	I	7X10⁻⁶	4X10⁻⁶	2X10⁻⁶	1X10⁻⁶
	In 114m	S	2X10⁻⁶	8X10⁻⁶	5X10⁻⁷	2X10⁻⁶
	In 114m	I	2X10⁻⁶	8X10⁻⁶	7X10⁻⁷	2X10⁻⁶
	In 115m	S	2X10⁻⁶	1X10⁻⁶	6X10⁻⁷	4X10⁻⁶
	In 115m	I	2X10⁻⁶	1X10⁻⁶	6X10⁻⁷	4X10⁻⁶
	In 115	S	3X10⁻⁶	8X10⁻⁶	9X10⁻⁷	3X10⁻⁶
	In 115	I	3X10⁻⁶	2X10⁻⁶	1X10⁻⁶	6X10⁻⁶
Iodine (53)	I 129	S	3X10⁻⁶	2X10⁻⁶	9X10⁻¹⁰	2X10⁻⁶
	I 129	I	3X10⁻⁶	2X10⁻⁶	1X10⁻⁶	6X10⁻⁶
	I 131	S	2X10⁻⁶	1X10⁻⁶	6X10⁻¹⁰	4X10⁻⁶
	I 131	I	7X10⁻⁶	6X10⁻⁶	2X10⁻⁶	2X10⁻⁶
	I 132	S	8X10⁻⁶	4X10⁻⁶	3X10⁻¹⁰	2X10⁻⁶
	I 132	I	3X10⁻⁶	2X10⁻⁶	1X10⁻⁶	6X10⁻⁶
	I 133	S	9X10⁻⁶	6X10⁻⁶	3X10⁻⁶	2X10⁻⁶
	I 133	I	3X10⁻⁶	2X10⁻⁶	1X10⁻⁶	7X10⁻⁶
	I 134	S	8X10⁻⁶	4X10⁻⁶	3X10⁻⁶	1X10⁻⁶
	I 134	I	3X10⁻⁶	2X10⁻⁶	1X10⁻⁶	6X10⁻⁶
	I 135	S	4X10⁻⁶	2X10⁻⁶	1X10⁻⁶	7X10⁻⁷
	I 135	I	4X10⁻⁶	2X10⁻⁶	1X10⁻⁶	7X10⁻⁷
Iridium (77)	Ir 190	S	3X10⁻⁶	6X10⁻⁶	4X10⁻⁶	2X10⁻⁶
	Ir 190	I	4X10⁻⁶	3X10⁻⁶	1X10⁻⁶	1X10⁻⁶
	Ir 192	S	3X10⁻⁶	1X10⁻⁶	4X10⁻⁶	4X10⁻⁶
	Ir 192	I	3X10⁻⁶	1X10⁻⁶	4X10⁻⁶	4X10⁻⁶
	Ir 194	S	3X10⁻⁶	1X10⁻⁶	9X10⁻¹⁰	4X10⁻⁶
	Ir 194	I	2X10⁻⁶	9X10⁻⁶	5X10⁻⁶	3X10⁻⁶
Iron (26)	Fe 55	S	9X10⁻⁶	2X10⁻⁶	3X10⁻⁶	8X10⁻⁶
	Fe 55	I	3X10⁻⁶	7X10⁻⁶	3X10⁻⁶	2X10⁻⁶
	Fe 59	S	3X10⁻⁶	2X10⁻⁶	8X10⁻⁶	6X10⁻⁶
	Fe 59	I	8X10⁻⁶	2X10⁻⁶	2X10⁻⁶	8X10⁻⁷
Krypton (36)	Kr 85m	Sub	8X10⁻⁶		1X10⁻⁶	
	Kr 85	Sub	3X10⁻⁶		3X10⁻⁶	
	Kr 87	Sub	1X10⁻⁶		2X10⁻⁶	
Lanthanum (57)	La 140	S	3X10⁻⁶	7X10⁻⁶	6X10⁻⁷	2X10⁻⁶
	La 140	I	1X10⁻⁶	3X10⁻⁶	4X10⁻⁷	2X10⁻⁶
Lead (82)	Pb 203	I	8X10⁻⁶	1X10⁻⁶	8X10⁻⁶	4X10⁻⁶
	Pb 210	I	9X10⁻⁶	1X10⁻⁶	5X10⁻⁶	6X10⁻⁶
	Pb 210	I	1X10⁻¹⁰	4X10⁻⁶	4X10⁻¹¹	1X10⁻⁶
	Pb 211	I	2X10⁻⁶	8X10⁻⁶	8X10⁻¹¹	2X10⁻⁶
	Pb 212	I	3X10⁻⁶	6X10⁻⁶	6X10⁻¹¹	2X10⁻⁶
Lutetium (71)	Lu 177	S	8X10⁻⁶	6X10⁻⁶	2X10⁻¹³	2X10⁻⁶
	Lu 177	I	6X10⁻⁶	3X10⁻⁶	3X10⁻⁶	1X10⁻⁶
Manganese (25)	Mn 52	S	2X10⁻⁶	1X10⁻⁶	2X10⁻⁶	1X10⁻⁶
	Mn 54	S	3X10⁻⁶	1X10⁻⁶	7X10⁻⁷	3X10⁻⁶
	Mn 56	S	1X10⁻⁶	9X10⁻⁶	5X10⁻⁶	3X10⁻⁶
	Mn 56	I	4X10⁻⁶	4X10⁻⁶	1X10⁻⁶	1X10⁻⁶
Mercury (80)	Hg 197m	S	4X10⁻⁶	3X10⁻⁶	1X10⁻⁶	1X10⁻⁶
	Hg 197m	I	8X10⁻⁶	4X10⁻⁶	3X10⁻⁶	1X10⁻⁶
	Hg 197	S	8X10⁻⁶	6X10⁻⁶	3X10⁻⁶	2X10⁻⁶
	Hg 197	I	7X10⁻⁶	6X10⁻⁶	3X10⁻⁶	2X10⁻⁶
	Hg 203	S	1X10⁻⁶	8X10⁻⁶	4X10⁻⁶	3X10⁻⁶
	Hg 203	I	1X10⁻⁶	8X10⁻⁶	5X10⁻⁶	3X10⁻⁶
Molybdenum (42)	Mo 99	I	1X10⁻⁶	3X10⁻⁶	2X10⁻⁶	1X10⁻⁶
Neodymium (60)	Nd 144	I	9X10⁻¹¹	1X10⁻⁶	4X10⁻¹¹	4X10⁻⁶
	Nd 147	I	6X10⁻⁶	4X10⁻⁶	2X10⁻⁶	1X10⁻⁶
	Nd 149	I	3X10⁻¹¹	2X10⁻⁶	1X10⁻¹¹	8X10⁻⁷

APPENDIX B

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—Continued

[See notes at end of table]

Element (atomic number)	Isotope	Table I		Table II	
		Column 1 Air (μc/ml)	Column 2 Water (μc/ml)	Column 1 Air (μc/ml)	Column 3 Water (μc/ml)
Neodymium (60)	Nd 147	4X10-8	2X10-4	1X10-6	6X10-4
	Nd 149	2X10-7	8X10-4	6X10-6	3X10-3
Neptunium (93)	Np 237	1X10-8	3X10-4	3X10-7	1X10-3
	Np 239	4X10-8	8X10-4	1X10-6	3X10-3
Nickel (28)	Ni 59	8X10-7	4X10-3	2X10-5	1X10-2
	Ni 63	3X10-7	6X10-3	3X10-6	2X10-2
	Ni 65	2X10-7	3X10-3	3X10-6	1X10-2
Niobium (Columbium) (41)	Nb 93m	8X10-8	3X10-3	2X10-6	1X10-2
	Nb 95	1X10-7	1X10-3	4X10-6	4X10-3
	Nb 97	2X10-7	6X10-3	5X10-6	2X10-2
Osmium (76)	Os 185	4X10-7	2X10-3	1X10-5	7X10-3
	Os 191m	3X10-6	3X10-2	9X10-5	1X10-1
	Os 191	2X10-7	6X10-4	5X10-6	2X10-3
	Os 193	4X10-7	2X10-3	1X10-5	7X10-3
Palladium (46)	Pd 103	3X10-7	2X10-3	1X10-5	6X10-3
	Pd 109	6X10-7	3X10-3	2X10-5	9X10-3
Phosphorus (15)	P 32	4X10-8	2X10-4	1X10-6	6X10-4
Platinum (78)	Pt 191	2X10-7	1X10-3	6X10-6	3X10-3
	Pt 193m	8X10-7	4X10-3	3X10-5	1X10-2
	Pt 197m	7X10-7	3X10-3	2X10-5	1X10-2
	Pt 197	6X10-7	3X10-3	2X10-5	1X10-2
Plutonium (94)	Pu 238	3X10-8	1X10-4	1X10-6	4X10-4
	Pu 239	3X10-8	1X10-4	1X10-6	4X10-4
	Pu 240	3X10-8	1X10-4	1X10-6	4X10-4
	Pu 241	1X10-6	6X10-3	4X10-5	2X10-2
	Pu 242	3X10-8	1X10-4	1X10-6	4X10-4
Polonium (84)	Po 210	6X10-8	2X10-4	2X10-6	8X10-4
Potassium (19)	K 42	2X10-7	9X10-4	6X10-6	3X10-3
Praseodymium (59)	Pr 142	1X10-7	6X10-4	4X10-6	2X10-3
	Pr 143	2X10-7	8X10-4	6X10-6	3X10-3
Promethium (61)	Pm 147	3X10-7	1X10-3	9X10-6	4X10-3
	Pm 149	1X10-7	6X10-4	4X10-6	2X10-3
Protactinium (91)	Pa 230	1X10-7	6X10-4	4X10-6	2X10-3
	Pa 231	3X10-9	1X10-5	9X10-8	4X10-5
	Pa 233	1X10-7	6X10-4	4X10-6	2X10-3
Radium (88)	Ra 223	2X10-8	9X10-5	6X10-7	3X10-4
	Ra 224	6X10-8	2X10-4	2X10-6	6X10-4
	Ra 226	2X10-10	1X10-6	6X10-9	3X10-6
	Ra 228	6X10-10	3X10-6	2X10-8	9X10-6
Radon (86)	Rn 220	3X10-7		1X10-5	
	Rn 222	1X10-7		3X10-6	
Rhenium (75)	Re 183	3X10-7	2X10-3	9X10-6	6X10-3
	Re 186	6X10-8	3X10-4	2X10-6	9X10-4
	Re 187	6X10-7	3X10-3	2X10-5	9X10-3
	Re 188	3X10-8	1X10-4	1X10-6	3X10-4
Rhodium (45)	Rh 103m	8X10-7	4X10-3	3X10-5	1X10-2
	Rh 105	6X10-7	3X10-3	2X10-5	1X10-2
Rubidium (37)	Rb 86	2X10-7	1X10-3	6X10-6	3X10-3
	Rb 87	1X10-7	6X10-4	4X10-6	2X10-3
Ruthenium (44)	Ru 97	8X10-7	4X10-3	3X10-5	1X10-2
	Ru 103	2X10-7	1X10-3	6X10-6	3X10-3
	Ru 105	6X10-7	3X10-3	2X10-5	1X10-2
	Ru 106	1X10-7	6X10-4	4X10-6	2X10-3
Samarium (62)	Sm 147	6X10-8	3X10-4	2X10-6	9X10-4
	Sm 151	6X10-8	3X10-4	2X10-6	9X10-4
	Sm 153	3X10-7	1X10-3	9X10-6	4X10-3
Scandium (21)	Sc 46	3X10-8	1X10-4	1X10-6	4X10-4
	Sc 47	1X10-7	6X10-4	4X10-6	2X10-3
	Sc 48	3X10-8	1X10-4	1X10-6	4X10-4
Selenium (34)	Se 75	1X10-7	6X10-4	4X10-6	2X10-3
Silicon (14)	Si 31	8X10-7	4X10-3	3X10-5	1X10-2
Silver (47)	Ag 105	2X10-7	1X10-3	6X10-6	3X10-3
	Ag 110m	1X10-7	6X10-4	4X10-6	2X10-3
	Ag 111	3X10-7	1X10-3	9X10-6	4X10-3
Sodium (11)	Na 22	3X10-8	1X10-4	1X10-6	4X10-4
	Na 24	2X10-7	1X10-3	6X10-6	3X10-3
Strontium (38)	Sr 85m	1X10-6	6X10-3	4X10-5	2X10-2
	Sr 85	3X10-8	1X10-4	1X10-6	4X10-4
	Sr 89	3X10-8	1X10-4	1X10-6	4X10-4

See footnotes at end of table.

APPENDIX B

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1 Air (μc/ml)	Column 2 Water (μc/ml)	Column 1 Air (μc/ml)	Column 2 Water (μc/ml)
Strontium (38)	Sr 90	S	3X10⁻¹⁰	6X10⁻⁶	1X10⁻¹⁰	1X10⁻⁶
	Sr 91	I	5X10⁻⁸	1X10⁻⁶	2X10⁻⁸	4X10⁻⁶
	Sr 92	I	6X10⁻⁷	3X10⁻⁶	2X10⁻⁷	1X10⁻⁵
		S	8X10⁻⁸	1X10⁻⁶	8X10⁻⁹	8X10⁻⁶
			4X10⁻⁸	2X10⁻⁶	1X10⁻⁸	7X10⁻⁶
Sulfur (16)	S 35	S	3X10⁻⁸	2X10⁻⁶	9X10⁻⁹	6X10⁻⁶
		I	3X10⁻⁸	6X10⁻⁶	8X10⁻⁹	2X10⁻⁵
Tantalum (73)	Ta 182	S	4X10⁻⁹	1X10⁻⁷	1X10⁻⁹	6X10⁻⁸
		I	3X10⁻⁸	1X10⁻⁷	7X10⁻⁹	4X10⁻⁸
Technetium (43)	Tc 96m	S	8X10⁻⁷	4X10⁻⁴	3X10⁻⁷	1X10⁻⁴
		I	3X10⁻⁶	3X10⁻⁴	1X10⁻⁶	1X10⁻⁴
	Tc 96	S	6X10⁻⁸	3X10⁻⁶	2X10⁻⁸	1X10⁻⁵
		I	2X10⁻⁷	1X10⁻⁶	8X10⁻⁹	6X10⁻⁶
	Tc 97m	S	2X10⁻⁷	1X10⁻⁵	8X10⁻⁸	4X10⁻⁵
		I	3X10⁻⁷	8X10⁻⁵	8X10⁻⁸	2X10⁻⁴
	Tc 97	S	1X10⁻⁶	8X10⁻⁵	4X10⁻⁸	2X10⁻⁴
		I	3X10⁻⁶	2X10⁻⁴	1X10⁻⁷	8X10⁻⁴
	Tc 98m	S	6X10⁻⁸	2X10⁻⁵	1X10⁻⁸	6X10⁻⁵
		I	1X10⁻⁷	8X10⁻⁵	4X10⁻⁸	3X10⁻⁴
	Tc 99	S	3X10⁻⁸	1X10⁻⁶	7X10⁻⁹	3X10⁻⁵
		I	6X10⁻⁸	4X10⁻⁶	2X10⁻⁸	1X10⁻⁵
Tellurium (52)	Te 125m	S	4X10⁻⁷	8X10⁻⁶	1X10⁻⁷	3X10⁻⁵
		I	1X10⁻⁷	3X10⁻⁶	4X10⁻⁸	1X10⁻⁵
	Te 127m	S	1X10⁻⁷	2X10⁻⁶	6X10⁻⁸	6X10⁻⁶
		I	4X10⁻⁸	2X10⁻⁶	1X10⁻⁸	6X10⁻⁶
	Te 127	S	2X10⁻⁶	8X10⁻⁵	6X10⁻⁸	3X10⁻⁴
		I	9X10⁻⁷	3X10⁻⁵	3X10⁻⁸	2X10⁻⁴
	Te 129m	S	8X10⁻⁸	1X10⁻⁵	3X10⁻⁹	3X10⁻⁵
		I	3X10⁻⁷	8X10⁻⁵	1X10⁻⁸	2X10⁻⁴
	Te 129	S	6X10⁻⁶	2X10⁻⁴	1X10⁻⁷	8X10⁻⁴
		I	6X10⁻⁷	3X10⁻⁵	1X10⁻⁸	8X10⁻⁵
	Te 131m	S	2X10⁻⁷	1X10⁻⁵	6X10⁻⁹	4X10⁻⁵
		I	2X10⁻⁷	9X10⁻⁵	7X10⁻⁹	3X10⁻⁴
	Te 132	S	1X10⁻⁷	6X10⁻⁶	3X10⁻⁹	2X10⁻⁵
		I	1X10⁻⁷	5X10⁻⁶	3X10⁻⁹	1X10⁻⁵
Terbium (65)	Tb 160	S	3X10⁻⁸	1X10⁻⁶	1X10⁻⁹	4X10⁻⁶
Thallium (81)	Tl 200	S	3X10⁻⁷	1X10⁻⁵	9X10⁻⁹	4X10⁻⁵
		I	1X10⁻⁷	7X10⁻⁵	4X10⁻⁹	2X10⁻⁴
	Tl 201	S	3X10⁻⁷	8X10⁻⁵	7X10⁻⁹	3X10⁻⁴
		I	9X10⁻⁷	8X10⁻⁵	3X10⁻⁸	3X10⁻⁴
	Tl 202	S	8X10⁻⁷	3X10⁻⁵	3X10⁻⁹	1X10⁻⁴
		I	3X10⁻⁷	2X10⁻⁵	8X10⁻⁹	7X10⁻⁵
	Tl 204	S	6X10⁻⁷	3X10⁻⁵	2X10⁻⁸	1X10⁻⁴
		I	5X10⁻⁶	2X10⁻⁴	9X10⁻⁸	6X10⁻⁴
Thorium (90)	Th 228	S	9X10⁻¹³	2X10⁻⁹	3X10⁻¹³	7X10⁻⁹
		I	6X10⁻¹²	2X10⁻⁸	2X10⁻¹²	7X10⁻⁹
	Th 230	S	2X10⁻¹³	8X10⁻⁹	3X10⁻¹³	3X10⁻⁸
		I	10⁻¹²	9X10⁻⁹	3X10⁻¹³	3X10⁻⁸
	Th 232	S	3X10⁻¹⁴	1X10⁻⁹	10⁻¹³	3X10⁻⁹
		I	3X10⁻¹³	10⁻⁸	10⁻¹³	4X10⁻⁹
	Th natural	S	3X10⁻¹⁴	1X10⁻⁹	10⁻¹³	3X10⁻⁹
		I	8X10⁻¹³	3X10⁻⁸	2E-13	10⁻⁸
	Th 234	S	8X10⁻⁷	3X10⁻⁵	2X10⁻⁸	1X10⁻⁴
		I	3X10⁻⁶	1X10⁻⁴	10⁻⁷	3X10⁻⁴
Thallium (37)	Tm 170	S	4X10⁻⁸	1X10⁻⁶	1X10⁻⁹	5X10⁻⁶
		I	3X10⁻⁸	1X10⁻⁶	1X10⁻⁹	5X10⁻⁶
	Tm 171	S	1X10⁻⁶	1X10⁻⁴	6X10⁻⁹	3X10⁻⁴
		I	1X10⁻⁶	1X10⁻⁴	6X10⁻⁹	3X10⁻⁴
Tin (50)	Sn 113	S	3X10⁻⁸	1X10⁻⁶	1X10⁻⁹	4X10⁻⁶
		I	4X10⁻⁸	1X10⁻⁶	1X10⁻⁹	5X10⁻⁶
	Sn 125	S	8X10⁻⁸	3X10⁻⁶	2X10⁻⁹	8X10⁻⁶
		I	1X10⁻⁷	8X10⁻⁶	4X10⁻⁹	2X10⁻⁵
	W 181	S	8X10⁻⁸	3X10⁻⁶	3X10⁻⁹	1X10⁻⁵
Tungsten (Wolfram) (74)		I	2X10⁻⁷	1X10⁻⁵	8X10⁻⁹	4X10⁻⁵
	W 185	S	1X10⁻⁷	1X10⁻⁵	4X10⁻⁹	3X10⁻⁵
		I	3X10⁻⁷	1X10⁻⁵	8X10⁻⁹	3X10⁻⁵
	W 187	S	1X10⁻⁷	3X10⁻⁶	4X10⁻⁹	1X10⁻⁵
		I	2X10⁻⁷	1X10⁻⁵	7X10⁻⁹	4X10⁻⁵
Uranium (92)	U 230	S	3X10⁻¹⁰	2X10⁻⁶	1X10⁻¹⁰	6X10⁻⁶
		I	3X10⁻⁹	2X10⁻⁶	1X10⁻¹⁰	6X10⁻⁶
	U 232	S	3X10⁻¹⁰	1X10⁻⁶	1X10⁻¹⁰	3X10⁻⁶
		I	3X10⁻⁹	1X10⁻⁶	1X10⁻¹⁰	3X10⁻⁶
	U 233	S	1X10⁻⁹	6X10⁻⁶	4X10⁻¹⁰	2X10⁻⁵
		I	1X10⁻⁸	6X10⁻⁶	4X10⁻¹⁰	2X10⁻⁵
	U 234	S	1X10⁻⁹	6X10⁻⁶	4X10⁻¹⁰	2X10⁻⁵
		I	1X10⁻⁸	6X10⁻⁶	4X10⁻¹⁰	2X10⁻⁵
	U 235	S	1X10⁻⁹	6X10⁻⁶	4X10⁻¹⁰	2X10⁻⁵
		I	1X10⁻⁸	6X10⁻⁶	4X10⁻¹⁰	2X10⁻⁵
	U 238	S	1X10⁻⁹	6X10⁻⁶	4X10⁻¹⁰	2X10⁻⁵
		I	1X10⁻⁸	6X10⁻⁶	4X10⁻¹⁰	2X10⁻⁵
	U nat	S	1X10⁻⁹	6X10⁻⁶	4X10⁻¹⁰	2X10⁻⁵
		I	1X10⁻⁸	6X10⁻⁶	4X10⁻¹⁰	2X10⁻⁵
	U-natural	S	1X10⁻⁹	6X10⁻⁶	4X10⁻¹⁰	2X10⁻⁵
		I	1X10⁻⁸	6X10⁻⁶	4X10⁻¹⁰	2X10⁻⁵
Vanadium (23)	V 48	S	3X10⁻⁸	1X10⁻⁶	1X10⁻⁹	4X10⁻⁶
		I	6X10⁻⁸	2X10⁻⁶	2X10⁻⁹	8X10⁻⁶
Xenon (54)	Xe 131m	Sub	2X10⁻⁶	.....	4X10⁻⁷	.....
	Xe 133	Sub	1X10⁻⁶	.....	3X10⁻⁷	.....
	Xe 135	Sub	4X10⁻⁶	.....	1X10⁻⁶	.....
Ytterbium (70)	Yb 175	S	7X10⁻⁸	3X10⁻⁶	2X10⁻⁹	1X10⁻⁵
		I	6X10⁻⁷	2X10⁻⁵	2X10⁻⁸	1X10⁻⁴
Yttrium (39)	Y 90	S	1X10⁻⁷	6X10⁻⁶	4X10⁻⁹	2X10⁻⁵
		I	1X10⁻⁷	6X10⁻⁶	3X10⁻⁹	2X10⁻⁵
	Y 91m	S	3X10⁻⁶	1X10⁻⁴	8X10⁻⁸	3X10⁻⁴
		I	3X10⁻⁶	1X10⁻⁴	6X10⁻⁸	3X10⁻⁴
	Y 91	S	4X10⁻⁸	1X10⁻⁶	1X10⁻⁹	3X10⁻⁶
		I	3X10⁻⁷	1X10⁻⁵	1X10⁻⁹	3X10⁻⁵
	Y 92	S	4X10⁻⁷	2X10⁻⁵	1X10⁻⁸	6X10⁻⁵
		I	3X10⁻⁷	2X10⁻⁵	1X10⁻⁸	6X10⁻⁵
	Y 93	S	2X10⁻⁷	1X10⁻⁵	6X10⁻⁹	3X10⁻⁵
		I	3X10⁻⁷	1X10⁻⁵	8X10⁻⁹	3X10⁻⁵
Zinc (30)	Zn 65	S	1X10⁻⁷	3X10⁻⁶	4X10⁻⁹	1X10⁻⁴
		I	1X10⁻⁷	3X10⁻⁶	4X10⁻⁹	1X10⁻⁴
	Zn 69m	S	6X10⁻⁸	2X10⁻⁵	2X10⁻⁹	7X10⁻⁵
		I	4X10⁻⁷	2X10⁻⁵	1X10⁻⁸	7X10⁻⁵
	Zn 69	S	4X10⁻⁷	2X10⁻⁵	1X10⁻⁸	6X10⁻⁵
		I	4X10⁻⁷	2X10⁻⁵	1X10⁻⁸	6X10⁻⁵
Zirconium (40)	Zr 93	S	3X10⁻⁸	2X10⁻⁶	4X10⁻⁹	8X10⁻⁶
		I	3X10⁻⁷	2X10⁻⁵	1X10⁻⁸	8X10⁻⁵
	Zr 95	S	1X10⁻⁷	2X10⁻⁵	4X10⁻⁹	6X10⁻⁵
		I	3X10⁻⁷	2X10⁻⁵	1X10⁻⁸	6X10⁻⁵
	Zr 97	S	1X10⁻⁷	8X10⁻⁶	4X10⁻⁹	2X10⁻⁵
		I	9X10⁻⁷	8X10⁻⁶	3X10⁻⁸	2X10⁻⁴

[1] Soluble (S); Insoluble (I).

[2] "Sub" means that values given are for submersion in an infinite cloud of gaseous material.

NOTE: In any case where there is a mixture in air or water of more than one radionuclide, the limiting values for purposes of this Appendix should be determined as follows:

1. If the identity and concentration of each radionuclide in the mixture are known, the limiting values should be derived as follows: Determine, for each radionuclide in the mixture, the ratio between the quantity present in the mixture and the limit otherwise established in Appendix B for the specific radionuclide when not in a mixture. The sum of such ratios for all 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 MPC's are MPC_A, and MPC_B, and MPC_C respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{MPC_A}+\frac{C_B}{MPC_B}+\frac{C_C}{MPC_C}\leq 1$$

2. If either the identity or the concentration of any radionuclide in the mixture is not known, the limiting values for purposes of Appendix B shall be:

a. For purposes of Table I, Col. 1—1×10^{-12}

b. For purposes of Table I, Col. 2—3×10^{-9}

c. For purposes of Table II, Col. 1—1×10^{-13}

d. For purposes of Table II, Col. 2—1×10^{-9}

3. If the conditions specified below are met, the corresponding values specified below may be used in lieu of those specified in paragraph 2 above.

Element (atomic number) and isotope	Table I		Table II	
	Column 1 Air (μc/ml)	Column 2 Water (μc/ml)	Column 1 Air (μc/ml)	Column 2 Water (μc/ml)
If it is known that Ac 90, I 129, Pb 210, At 211, Ra 223, Ra 224, Th 227, Ac 228, Th 230, Th 231, and their daughters are present		9×10^{-6}		3×10^{-6}
If it is known that Ra 223, I 129, Pb 210, Bi 223, Ra 224, Th 227, Th 230, and Th 231 are not present		6×10^{-6}		3×10^{-6}
If it is known that Ac 90, Pa 231, Bi 210 and Ra 226 are not present		3×10^{-6}		6×10^{-6}
If it is known that Ra 226 and Bi 210 are not present		3×10^{-6}		1×10^{-6}
If it is known that Ac 90, I 129, Pb 210, Ac 227, Ra 224, Th 227, Th 230, Th 231 and Bk 249 are not present	8×10^{-7}		1×10^{-10}	
If it is known that alpha emitters and Pb 210, Ac 227, Ra 226, and Pa 231 are not present	3×10^{-10}		1×10^{-11}	
If it is known that alpha emitters and Ac 227 are not present	9×10^{-11}		1×10^{-11}	
If it is known that Ac 227, Pb 210, Pa 231, Pu 238, Pa 225, Pu 236, Th 227, and Cf 249 are not present	2×10^{-11} 2×10^{-9}		1×10^{-9} 7×10^{-11}	
If Pa 231, Pa 226, Pa 229, Pb 212 and Cf 249 are not present				

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

5010-107

UNITED STATES GOVERNMENT

Memorandum

TO : Heads of Divisions and Offices, HQ
Managers of Field Offices

DATE: August 12, 1965

FROM : Nathan H. Woodruff, Director
Division of Operational Safety

SUBJECT: PROPOSED AMENDMENT TO 10 CFR PART 20, RADIOACTIVITY CONCENTRATIONS IN AIR AND WATER

OS:HP:CGW

Attached for your review and comment is the subject proposal as published for a 60-day comment period in the August 10, 1965, issue of the Federal Register.

Since we are considering including these provisions in AEC Manual Chapter 0524, "Standards for Radiation Protection", we are desirous that AEC offices and contractors have an opportunity to review them thoroughly during the comment period and prior to their adoption into 10 CFR Part 20, "Standards for Protection Against Radiation". Comments should be submitted to the Director, Division of Operational Safety, by September 24, 1965, so we will have sufficient time to advise the Director of Regulation of the General Manager's position on the proposal.

Attachment:
As stated

Attachment

ATOMIC ENERGY COMMISSION

[10 CFR Part 20]

STANDARDS FOR PROTECTION AGAINST RADIATION

Radioactivity Concentrations in Air and Water

On September 7, 1960, the Commission published in the FEDERAL REGISTER several amendments of 10 CFR Part 20, effective January 1, 1961. The amendments included a comprehensive revision of the values specified in 10 CFR Part 20, Appendix B—Concentrations in Air and Water Above Natural Background. The revised values were based upon recommendations of the National Committee on Radiation Protection and Measurements (NCRP), as published in National Bureau of Standards Handbook 69, "Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure." The recommendations of the International Commission on Radiological Protection (ICRP), as published in the "Report of Committee II on Permissible Dose for Internal Radiation," were essentially the same as those of the NCRP. The only subsequent change of these values was an amendment of 10 CFR Part 20, effective November 20, 1964, which revised the values in Appendix B for certain isotopes of iodine, radium, and strontium, based on Federal Radiation Council (FRC) recommendations.

The amendment proposed herein modifies 10 CFR Part 20, Appendix B, in the following ways:

(a) It would provide values for certain individual radionuclides not presently listed;

(b) It would provide generally applicable values for any radionuclides not individually listed;

(c) It would revise existing values for occupational exposure to soluble strontium-90; and

(d) It would modify the footnotes and the Note following Appendix B to make them consistent with other changes to the Appendix.

In the course of the administration of the Commission's regulatory program, needs have arisen for concentration values for certain radionuclides, which are not presently listed in Appendix B, and which have not been specifically developed by any of the recommendatory bodies, namely the ICRP, the NCRP, and the FRC. The Commission has developed the needed values by methods consistent with those used by the ICRP and NCRP to develop recommended concentration values for the nuclides presently listed in Appendix B. In addition, concentration values are proposed for insoluble forms of tritium. The concentration values for these additional nuclides are listed in paragraph 1.(a) of the proposed amendment. The considerations on which the values are based include the following:

(a) For iodine-128, the values in Table II have been made consistent with the intake guides recommended by the FRC for iodine-131 by taking into account the effective half-life and absorbed radiation energy.

(b) Presently, Appendix B does not contain concentration values for tritium in insoluble materials, such as luminous compounds, which are finding increasing use. Calculation according to ICRP–NCRP methodology would give air concentration values about a factor of 7 less, and water values about a factor of 2 less, than those for soluble forms. However, it is likely that much of the soft beta particle energy will not be absorbed in tissue, and on this basis higher concentration values would be appropriate. In view of these considerations and of the technical difficulties in distinguishing soluble and insoluble components, concentration values numerically equal to the existing values for soluble forms are proposed for inclusion in Appendix B for insoluble forms of tritium.

(c) For relatively short-lived nuclides (half-lives less than 2 hours), not already specifically listed in Appendix B and decaying by modes other than alpha emission or spontaneous fission, it is unlikely that air concentration values will be less, and they cannot be greater (whether or not they are gases), than those based on submersion. To avoid the necessity to identify the individual nuclides which may be present, generally applicable values for such nuclides are proposed using a submersion calculation based on the assumption that the average energy per distintegration is not likely to be greater than about 2 Mev.

During 1964, the ICRP published the "Recommendations of the International Commission on Radiological Protection (as amended 1959 and revised 1962), ICRP Publication 6." In Table I of "Publication 6," ICRP has recommended concentration values not previously developed for uranium-240 and nineteen transuranic nuclides. The proposed amendment includes, in paragraph 1.(b), values for these nuclides in Appendix B, based on the ICRP values. The ICRP has made revisions to previously recommended values for soluble forms of strontium-90,[1] which represent an increase over previous values of about a factor of three, based on evidence that the biological half-life is shorter than previously assumed. The proposed amendment includes, in paragraph 2., these revised values in Table I for soluble strontium-90; the values in Table II for soluble strontium-90 are not changed from the revised values made effective in November 1964, which were based on FRC recommendations for the guidance of Federal agencies.

Although it is believed that, with the proposed amendment, Appendix B includes specific values for all nuclides currently of some radiological significance, other nuclides not specifically listed may become significant sources of exposure at some future time. Therefore, the proposed amendment also provides, in paragraph 1.(c), generally applicable values for any radionuclide not specifically listed, or covered by the short half-life category, based on the most restrictive values likely to be applied. The values proposed for any single unlisted nuclide that decays by alpha emission or spontaneous fission are those listed in paragraph 2. of the Note following Appendix B, as revised below; the values proposed for any other single, unlisted nuclide are the least restrictive of those appearing in paragraph 3.c. of the Note following Appendix B.

Finally, the proposed amendment, in paragraph 3., makes certain modifications to the footnotes and the Note following Appendix B, as follows:

(a) In the second footnote, the word "gaseous" has been replaced with the word "airborne," since the submersion calculation has been extended to materials not necessarily in the gaseous form; in addition the word "semispherical" has been added to make clear the geometrical basis of the submersion calculation;

(b) Paragraphs 2. and 3.c. of the Note following Appendix B are revised to make them consistent with the values contained in Appendix B as revised.

Pursuant to the Atomic Energy Act of 1954, as amended, and the Administrative Procedure Act of 1946, notice is hereby given that adoption of the following amendment of 10 CFR Part 20 is contemplated. All interested persons who desire to submit written comments or suggestions in connection with the proposed amendment should send them to the Secretary, U.S. Atomic Energy Commission, Washington, D.C., 20545, within 60 days after publication of this notice in the FEDERAL REGISTER. Comments received after that period will be considered if it is practicable to do so, but assurance of consideration cannot be given except as to comments filed within the period specified.

---

[1] In "Publication 6," the ICRP also recommends certain changes applicable to soluble uranium. These recommendations are under study.

1. 10 CFR Part 20, Appendix B—Concentrations in Air and Water Above Natural Background, is amended to include the following radionuclides:

APPENDIX B

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)	Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
(a)						
Hydrogen (1)	H 3		2X10⁻⁶	1X10⁻³	2X10⁻⁶	2X10⁻³
Iodine (53)	I 131		6X10⁻⁹	4X10⁻⁷	6X10⁻⁹	3X10⁻⁷
			3X10⁻⁷	8X10⁻⁶	6X10⁻⁷	2X10⁻⁵
Krypton (36)	Kr 85	Sub [2]	1X10⁻⁶		2X10⁻⁶	
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		Sub	1X10⁻⁶		2X10⁻⁶	
• • •	• • •		• • •	• • •	• • •	• • •
(b)						
Americium (95)	Am 242m		6X10⁻¹⁰	1X10⁻⁷	2X10⁻⁹	4X10⁻⁷
	Am 242		2X10⁻⁸	2X10⁻⁷	6X10⁻⁸	6X10⁻⁷
	Am 241		6X10⁻⁹	4X10⁻⁷	1X10⁻⁸	1X10⁻⁶
	Am 244		8X10⁻⁹	4X10⁻⁷	2X10⁻⁸	1X10⁻⁶
Berkelium (97)	Bk 249		4X10⁻⁶	1X10⁻⁴	1X10⁻⁷	3X10⁻⁶
			1X10⁻⁷	1X10⁻⁷	3X10⁻⁷	3X10⁻⁶
Californium (98)	Cf 251		1X10⁻⁷	8X10⁻⁷	3X10⁻⁷	2X10⁻⁶
	Cf 249		2X10⁻⁸	1X10⁻⁷	4X10⁻⁸	3X10⁻⁶
	Cf 250		8X10⁻⁹	3X10⁻⁷	2X10⁻⁸	2X10⁻⁶
	Cf 252		2X10⁻⁸	1X10⁻⁶	4X10⁻⁸	4X10⁻⁶
	Cf 254		8X10⁻¹⁰	4X10⁻⁸	2X10⁻⁹	1X10⁻⁷
Curium (96)	Cm 247		2X10⁻⁸	1X10⁻⁷	4X10⁻⁸	3X10⁻⁶
	Cm 245		1X10⁻⁸	9X10⁻⁷	3X10⁻⁸	3X10⁻⁶
	Cm 243		6X10⁻⁹	1X10⁻⁷	2X10⁻⁸	4X10⁻⁷
	Cm 242		1X10⁻⁷	6X10⁻⁷	4X10⁻⁷	1X10⁻⁵
			1X10⁻⁷	6X10⁻⁷	4X10⁻⁷	
Einsteinium (99)	Es 253		1X10⁻⁷	8X10⁻⁷	4X10⁻⁷	
	Es 254m		8X10⁻⁹	7X10⁻⁷	3X10⁻⁸	
	Es 254		6X10⁻⁹	7X10⁻⁷	2X10⁻⁸	
	Es 255		8X10⁻⁹	8X10⁻⁷	3X10⁻⁸	
Fermium (100)	Fm 254		8X10⁻⁹	8X10⁻⁷	3X10⁻⁸	
	Fm 255		3X10⁻⁸	4X10⁻⁷	1X10⁻⁷	1X10⁻⁵
	Fm 253		1X10⁻⁸	4X10⁻⁷	6X10⁻⁸	1X10⁻⁵
	Fm 257		8X10⁻¹⁰	8X10⁻⁷	3X10⁻⁹	3X10⁻⁵
Plutonium (94)	Pu 239		4X10⁻¹⁰	8X10⁻⁷	1X10⁻⁹	3X10⁻⁵
	Pu 241		6X10⁻⁸	4X10⁻⁷	2X10⁻⁷	1X10⁻⁵
			7X10⁻⁹	1X10⁻⁷	2X10⁻⁸	4X10⁻⁶
			1X10⁻⁸	1X10⁻⁷	4X10⁻⁸	4X10⁻⁶
			8X10⁻⁹	9X10⁻⁷	3X10⁻⁸	3X10⁻⁵
			2X10⁻⁸	1X10⁻⁷	6X10⁻⁸	4X10⁻⁶
			2X10⁻⁸	1X10⁻⁷	6X10⁻⁸	4X10⁻⁶
			2X10⁻⁸	1X10⁻⁷	6X10⁻⁸	4X10⁻⁶
Uranium (92)	U 233		3X10⁻⁸	1X10⁻⁷	1X10⁻⁷	4X10⁻⁶
			3X10⁻⁷	1X10⁻⁶	8X10⁻⁷	3X10⁻⁵
(c)						
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			3X10⁻⁹	9X10⁻⁹	1X10⁻⁸	2X10⁻⁶
Any single radionuclide not listed above, which decays by alpha emission or spontaneous fission			6X10⁻¹²	4X10⁻⁷	2X10⁻¹¹	2X10⁻⁶

2. 10 CFR Part 20, Appendix B—Concentrations in Air and Water Above Natural Background, is amended by deleting the existing concentration values, and substituting therefor the indicated values for the following nuclides:

APPENDIX B—Continued

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—continued

[See notes at end of appendix]

Element (atomic number)	Isotope		Table I		Table II	
			Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)	Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
• • •	• • •	•	• • •	• • •	• • •	• • •
Strontium (38)	Sr 89		1X10⁻⁶	1X10⁻⁴	No change.	No change.

3. The footnotes and the Note following 10 CFR Part 20, Appendix B—Concentrations in Air and Water Above Natural Background, are amended to read as follows:

[1] Soluble (S); Insoluble (I).

[2] "Sub" means that values given are for submersion in a semispherical infinite cloud of airborne material.

Note: • • •

2. If either the identity or the concentration of any radionuclide in the mixture is not known, the limiting values for purposes of Appendix B shall be:

a. For purposes of Table I, Col. 1—6×10^{-13}

b. For purposes of Table I, Col. 2—4×10^{-7}

c. For purposes of Table II, Col. 1—2×10^{-11}

d. For purposes of Table II, Col. 2—3×10^{-7}

3. • • •

c. Element (atomic number) and isotope	Table I		Table II	
	Column 1 Air (μc/ml)	Column 2 Water (μc/ml)	Column 1 Air (μc/ml)	Column 2 Water (μc/ml)
If it is known that Sr 90, I 125, I 126, I 129, I 131 (I 129, Table II only), Pb 210, Po 210, At 211, Ra 223, Ra 224, Ra 226, Ac 227, Ra 228, Th 230, Pa 231, Th 232, Th-nat, Cm 248, Cf 254, and Fm 256 are not present		6×10^{-8}		2×10^{-6}
If it is known that Sr 90, I 125, I 126, I 129 (I 131, I 129, Table II only), Pb 210, Po 210, Ra 223, Ra 226, Ra 228, Pa 231, Th-nat, Cm 248, Cf 254, and Fm 256 are not present		6×10^{-8}		2×10^{-6}
If it is known that Sr 90, I 129 (I 125, I 126, I 131, Table II only), Pb 210, Ra 226, Ra 228, Cm 248, and Cf 254 are not present		2×10^{-8}		6×10^{-7}
If it is known that (I 129, Table II only), Ra 226, and Ra 228 are not present		2×10^{-8}		1×10^{-7}
If it is known that alpha-emitters and Sr 90, I 129, Pb 210, Ac 227, Ra 228, Pa 230, Pu 241, and Bk 249 are not present	2×10^{-9}		1×10^{-11}	
If it is known that alpha-emitters and Pb 210, Ac 227, Ra 228, and Pu 241 are not present	2×10^{-10}		1×10^{-11}	
If it is known that alpha-emitters and Ac 227 are not present	2×10^{-11}		1×10^{-12}	
If it is known that Ac 227, Th 230, Pa 231, Pu 238, Pu 239, Pu 240, Pu 242, Pu 244, Cm 248, Cf 249, and Cf 252 are not present	2×10^{-12}		1×10^{-12}	
If it is known that Pa 231, Pu 239, Pu 240, Pu 242, Pu 244, Cm 248, Cf 249, and Cf 251 are not present	2×10^{-12}		7×10^{-13}	

(Sec. 161, 68 Stat. 948; 42 U.S.C. 2201)

Dated at Germantown, Md., this 27th day of July 1965.

For the Atomic Energy Commission.

W. B. McCool,
Secretary.

[F.R. Doc. 65-8247; Filed, Aug. 9, 1965; 8:45 a.m.]

AEC

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

No. IN-644
Tel. 973-3335 or
973-3446

FOR IMMEDIATE RELEASE
(Tuesday, November 23, 1965)

AEC EXTENDS RETENTION PERIOD FOR RADIATION EXPOSURE RECORDS

The Atomic Energy Commission is amending its regulations to extend the period for maintaining records of individual radiation exposures.

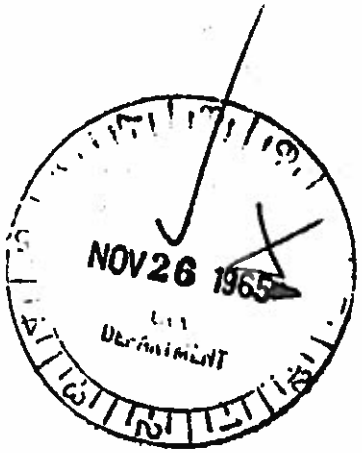
The amendment to Part 20 of Commission regulations - "Standards for Protection Against Radiation" - requires a licensee to maintain records showing the radiation exposures of all individuals for whom personnel monitoring is required until December 31, 1970, or five years after termination of employment, whichever is later. The date previously used in the regulation was December 31, 1965.

Various studies concerned with radiation injury, workmen's compensation laws and the correlation of radiation exposures with lifetime health and mortality experience are now being carried out. A further amendment to Part 20 may be made if the studies indicate a need for long-term retention of radiation exposure records. In the meantime, the five-year extension will assure that such records are not prematurely destroyed.

The amendment to Part 20 is the same as that previously published for public comment and will be effective 30 days after publication in the Federal Register on November 23, 1965.

#

11/23/65



(Reprint from 29 Federal Register, 14434, October 21, 1964)

Title 10—ATOMIC ENERGY

Chapter I—Atomic Energy Commission

PART 20—STANDARDS FOR PROTECTION AGAINST RADIATION

Radioactivity in Effluents to Unrestricted Areas

On September 17, 1963, the Commission published for public comment a proposed amendment of 10 CFR Part 20 which would revise § 20.106 and would revise Appendix "B" to Part 20 with respect to limits on release of certain radioactive materials into air or water in unrestricted areas.

The Statement of Considerations published in the FEDERAL REGISTER of September 17, 1963 (28 F.R. 10170) set forth a detailed discussion of the background and basis for the proposed amendment.

The amendment implements the recommendations of the September 13, 1961, Federal Radiation Council Memorandum for the President as they pertain to the release of effluent containing radioactive material from AEC-licensed activities in the following ways:

a. It would incorporate into Part 20 revised concentration limits based on FRC recommendations, for radium 226, iodine 131, strontium 89, and strontium 90 that would govern the release by licensees of these radionuclides into unrestricted areas. The limits for radium 226, and strontium 90 are less restrictive by a factor of 3. The limits for strontium 89 in air and water and for iodine 131 in air are more restrictive by a factor of 3, and the limit for iodine 131 in water is more restrictive by a factor of 7, than the present Part 20 limits.

b. It would add to § 20.106 a provision relating to limitations on the gross quantity of radioactive material released from a licensed activity in specified periods of time that will in specific circumstances be in addition to and concurrent with limitations on concentrations.

c. It would amend § 20.106 to require more specific information in support of applications for authority to release concentrations of radioactive material in effluents which exceed Part 20, Appendix "B" Table II limits.

d. It would amend criteria for approval of proposed limits higher than the Part 20 Appendix "B" limits to require the applicant to demonstrate that he has taken reasonable steps to minimize the radioactivity discharged in the effluent streams.

The amendment published below is essentially as set forth in the proposed rule, although several minor revisions have been made for clarity and completeness. This revision reflects Commission consideration of the comments and suggestions received in response to the notice of proposed rule making.

A number of language changes have been made, proposed paragraphs (b) and (c) have been combined, and the subsequent paragraphs have been relettered.

Paragraph 20.106(c) has been modified to implement § 20.106(b) by stating that an application for higher concentration limits shall make the demonstrations required by § 20.106(b).

The second sentence of § 20.106(d) has been modified to eliminate any implication that determination of the concentration discharged through a conduit must be made by measurement at the point of discharge. The modified language would allow concentrations at the point at which material leaves a conduit to be determined from measurement at other points along the conduit or from other known data. If the concentration at the end of a conduit through which radioactive material is discharged is determined to be within the limits specified in § 20.106(a), the licensee has complied with the limits on concentrations of radioactive material in effluents to unrestricted areas. This provision is consistent with § 20.106(c) of the presently effective regulation.

The Commission is also amending § 20.306, *Treatment or disposal by incineration*, to refer to the appropriate paragraph, (b), in the revised § 20.106.

The concentration limits for the other isotopes of iodine listed in Appendix "B", Table II, 10 CFR Part 20, have been revised to make them consistent with the intake guides recommended by the FRC for iodine 131, taking into account the effective half-life and absorbed radiation energy of the individual iodine radionuclides.

Pursuant to the Atomic Energy Act of 1954, as amended, and the Administrative Procedure Act of 1946, the following amendment of Title 10, Chapter I, Part 20, "Standards for Protection Against Radiation", is published as a document subject to codification to be effective thirty (30) days after publication in the FEDERAL REGISTER.

1. 10 CFR § 20.106 is amended to read as follows:

§ 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 (p^H) 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

(ii) In water at points of use downstream from the point of release of the effluent.

(5) The background concentration of radionuclides in the receiving river or stream prior to the release of liquid effluent.

(6) A description of the environmental monitoring equipment, including sensitivity of the system, and procedures and calculations to determine concentrations of radionuclides in the unrestricted area and possible reconcentrations of radionuclides.

(7) A description of the waste treatment facilities and procedures used to reduce the concentration of radionuclides in effluents prior to their release.

(d) For the purposes of this section the concentration limits in Appendix "B", Table II of this part shall apply at the

boundary of the restricted area. The concentration of radioactive material discharged through a stack, pipe or similar conduit may be determined with respect to the point where the material leaves the conduit. If the conduit discharges within the restricted area, the concentration at the boundary may be determined by applying appropriate factors for dilution, dispersion, or decay between the point of discharge and the boundary.

(e) In addition to limiting concentrations in effluent streams, the Commission may limit quantities of radioactive materials released in air or water during a specified period of time if it appears that the daily intake of radioactive material from air, water, or food by a suitable sample of an exposed population group, averaged over a period not exceeding one year, would otherwise exceed the daily intake resulting from continuous exposure to air or water containing one-third the concentration of radioactive materials specified in Appendix "B", Table II of this part.

(f) The provisions of this section do not apply to disposal of radioactive material into sanitary sewerage systems, which is governed by § 20.303

2. 10 CFR Part 20, Appendix "B", "Concentrations in Air and Water Above Natural Background", Table II, Column 1 and Column 2, is amended by deleting the concentration limits appearing in Table II, Column 1 and Column 2 for iodine (53), $I^{129}S$, $I^{130}S$, $I^{131}S$, $I^{132}S$, $I^{133}S$, $I^{134}S$, $I^{135}S$; radium (88) $Ra^{224}S$; strontium (38), $Sr^{89}S$ and $Sr^{90}S$ and substituting therefor the following limits:

Element (atomic number)	Isotope [1]	Table II	
		Column 1 air (μc/ml)	Column 2 water (μc/ml)
Iodine (53).....	$I^{129}S$	9×10^{-8}	2×10^{-7}
	$I^{130}S$	2×10^{-8}	6×10^{-8}
	$I^{131}S$	1×10^{-10}	2×10^{-1}
	$I^{132}S$	3×10^{-7}	8×10^{-6}
	$I^{133}S$	4×10^{-9}	1×10^{-7}
	$I^{134}S$	6×10^{-7}	2×10^{-5}
	$I^{135}S$	1×10^{-8}	4×10^{-7}
Strontium (38).....	$Sr^{89}S$	3×10^{-8}	3×10^{-7}
	$Sr^{90}S$	3×10^{-11}	3×10^{-7}
Radium (88).....	$Ra^{224}S$	3×10^{-10}	3×10^{-6}

[1] Soluble (S).

3. 10 CFR, § 20.305 is amended to read as follows:

§ 20.305 Treatment or disposal by incineration.

No licensee shall treat or dispose of licensed material by incineration except as specifically approved by the Commission pursuant to §§ 20.106(b) and 20.302.

(Sec. 161, 68 Stat. 948; 42 U.S.C. 2201)

Dated at Washington, D.C., this 5th day of October 1964.

For the Atomic Energy Commission.

W. B. McCool,
Secretary to the Commission.

[F.R. Doc. 64-10063; Filed, Oct. 20, 1964; 8:45 a.m.]

*Correction
I131S should read
I134S (29FR 14661)

GPO 883-510

PART 30

RULES OF GENERAL APPLICABILITY TO LICENSING OF BYPRODUCT MATERIAL

GENERAL PROVISIONS

§ 30.1 Purpose and scope.

This part prescribes rules governing licensing of byproduct material under the Atomic Energy Act of 1954, as amended (68 Stat. 919), and exemptions from the licensing requirements permitted by section 81 of the Act, applicable to all persons in the United States.

30 FR 8185

§ 30.2 Resolution of conflict.

The requirements of this part are in addition to, and not in substitution for, other requirements of this chapter. In any conflict between the requirements in this part and a specific requirement in another part of the regulations in this chapter, the specific requirement governs.

§ 30.3 Activities requiring license.

Except for persons exempt as provided in this part and Part 150 of this chapter, no person shall manufacture, produce, transfer, receive, acquire, own, possess, use, import or export byproduct material except as authorized in a specific or general license issued pursuant to the regulations in this chapter.

§ 30.4 Definitions.

As used in this part and Parts 31–36 of this chapter:

(a) "Act" means the Atomic Energy Act of 1954, including any amendments thereto;

(b) Terms defined in section 11 of the Act shall have the same meaning when used in the regulations in this part and Parts 31–36 to the extent such terms are not specifically defined in this part;

(c) "Agreement State" means any State with which the Commission has entered into an effective agreement under subsection 274b. of the Act. "Non-agreement State" means any other State;

(d) "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;

(e) "Commission" means the Atomic Energy Commission and its duly authorized representatives;

(f) "Curie" means that amount of radioactive material which disintegrates at the rate of 37 billion atoms per second;

(g) "Government agency" means 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;

(h) "Human use" means the internal or external administration of byproduct material, or the radiation therefrom, to human beings;

(i) "License", except where otherwise specified means a license for byproduct material issued pursuant to the regulations in this chapter;

(j) "Microcurie" means that amount of radioactive material which disintegrates at the rate of 37 thousand atoms per second;

(k) "Person" means (1) any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency other than the Commission, any State or any political subdivision of, or any political entity within a State, any foreign government or nation or any political subdivision of any such government or nation, or other entity; and (2) any legal successor, representative, agent, or agency of the foregoing;

(l) "Physician" means an individual licensed by a State or territory of the United States, the District of Columbia or the Commonwealth of Puerto Rico to dispense drugs in the practice of medicine;

(m) "Production facility" means production facility as defined in the regulations contained in Part 50 of this chapter;

(n) "Radiographer" means any individual who performs or who, in attendance at the site where the sealed source or sources are being used, personally supervises radiographic operations and who is responsible to the licensee for assuring compliance with the requirements of the Commission's regulations and the conditions of the license;

(o) "Radiographer's assistant" means any individual who, under the personal supervision of a radiographer, uses radiographic exposure devices, sealed sources or related handling tools, or survey instruments in radiography;

(p) "Radiography" means the examination of the structure of materials by nondestructive methods, utilizing sealed sources of byproduct materials;

(q) "Research and development" means (1) theoretical analysis, exploration, or experimentation; or (2) the extension of investigative findings and theories of a scientific or technical nature into practical application for experimental and demonstration purposes, including the experimental production and testing of models, devices, equipment, materials and processes. "Research and development" as used in this part and Parts 31–36 does not include the internal or external administration of byproduct material, or the radiation therefrom, to human beings;

(r) "Sealed source" means any byproduct material that is encased in a capsule designed to prevent leakage or escape of the byproduct material;

(s) "Source material" means source material as defined in the regulations contained in Part 40 of this chapter;

(t) "Special nuclear material" means special nuclear material as defined in the regulations contained in Part 70 of this chapter;

(u) "United States", when used in a geographical sense, includes all territories and possessions of the United States, the Canal Zone and Puerto Rico;

(v) "Utilization facility" means a utilization facility as defined in the regulations contained in Part 50 of this chapter.

§ 30.5 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part and Parts 31–36 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.

§ 30.6 Communications.

Except where otherwise specified, all communications and reports concerning the regulations in this part and Parts 31–36 and applications filed under them, should be addressed to the Director of Regulation, U.S. Atomic Energy Commission, Washington, D.C., 20545. Communications, reports and applications may be delivered in person at the Commission's offices at 1717 H Street NW., Washington, D.C.; at 4915 St. Elmo Avenue, Bethesda, Md.; or at Germantown, Md.

EXEMPTIONS

§ 30.11 Exemptions from licensing.

The Commission may upon the application of any interested person, or upon its own initiative, exempt certain classes or quantities of byproduct material or kinds of uses or users from the requirements for a license set forth in section 81 of the Act and in the regulations in this part and Parts 31–36 when it makes a finding that the exemption of such classes or quantities of such material or such kinds of uses or users will not constitute an unreasonable risk to the common defense and security and to the health and safety of the public.

§ 30.12 Persons using byproduct material under certain Atomic Energy Commission contracts.

Any prime contractor of the Commission is exempt from the requirements for a license set forth in sections 81 and 82 of the Act and from the regulations in this part to the extent that such contractor, under his prime contract with the Commission, manufactures, produces, transfers, receives, acquires, owns, possesses, uses, imports, or exports byproduct material for: (a) The performance of work for the Commission at a United States Government-owned or controlled site, including the transportation of byproduct material to or from such site and the performance of contract services during temporary interruptions of such transportation; (b) research in, or development, manufacture, storage, testing or transportation of, atomic weapons or components thereof; or (c) the use or operation of nuclear reactors or other nuclear devices in a United States Government-owned vehicle or vessel. In addition to the foregoing exemptions, any prime contractor or subcontractor of the Commission is exempt from the requirements for a license set forth in sections 81 and 82 of the Act and from the regulations in this part to the extent that such prime contractor or subcontractor manufactures, produces, transfers, receives, acquires, owns, possesses, uses, imports or exports byproduct material under his prime contract or subcontract when the Commission determines that the exemption of the prime contractor or subcontractor is authorized by law; and that, under the terms of the contract or subcontract, there is adequate assurance that the work thereunder can be accomplished without undue risk to the public health and safety. Any person exempt from licensing under this part prior to the effective date of this amendment who would otherwise be required by virtue of this section to obtain a license shall continue to be so exempt on an interim basis. Such interim exemption shall expire 60 days from the effective date of this amendment, unless within said 60-day period either an application for a license covering the activity or an application for an appropriate exemption under this section is filed with the Commission. If either such application is filed within such 60-day period, the interim exemption shall remain in effect until final action in the matter is taken by the Commission.

§ 30.13 Carriers.

Common and contract carriers and the United States Post Office Department are exempt from the regulations in this part and Parts 31–36 and the requirements for a license set forth in section 81 of the Act to the extent that they transport byproduct material in the regular course of their business as carriers.

§ 30.14 Exempt concentrations.

(a) Except as provided in paragraphs (c) and (d) of this section, any person is exempt from the requirements for a license set forth in section 81 of the Act and from the regulations in this part and Parts 31–36 of this chapter to the extent that such person receives, possesses, uses, transfers, owns or acquires products or materials containing byproduct material in concentrations not in excess of those listed in § 30.70.

(b) This section shall not be deemed to authorize the import of byproduct material or products containing byproduct material.

(c) A manufacturer, processor, or producer of a product or material in an agreement State is exempt from the requirements for a license set forth in section 81 of the Act and from the regulations in this part and Parts 31, 32, 33, 34 and 36, to the extent that he transfers byproduct material contained in a product or material in concentrations not in excess of those specified in § 30.70 and introduced into the product or material by a licensee holding a specific license issued by an agreement State or the Commission expressly authorizing such introduction. This exemption does not apply to the transfer of byproduct material contained in any food, beverage, cosmetic, drug, or other commodity or product designed for ingestion or inhalation by, or application to, a human being.

(d) No person may introduce byproduct material into a product or material knowing or having reason to believe that it will be transferred to persons exempt under this section or equivalent regulations of an agreement State, except in accordance with a license issued pursuant to § 32.11 of this chapter or the general license provided in § 150.20 of Part 150.

§ 30.15 Certain items containing tritium or promethium 147.

(a) Except for persons who apply tritium or promethium 147 to, or persons who incorporate tritium or promethium 147 into, the following products, or persons who import for sale or distribution the following products containing tritium or promethium 147, any person is exempt from the requirements for a license set forth in section 81 of the Act and from the regulations in Parts 20 and 30–36 of this chapter to the extent that such person receives, possesses, uses, transfers, exports, owns, or acquires the following products:

(1) Timepieces or hands or dials containing not more than the following specified quantities of byproduct material and not exceeding the following specified levels of radiation:

(i) 25 millicuries of tritium per timepiece,

(ii) 5 millicuries of tritium per hand,

(iii) 15 millicuries of tritium per dial (bezels when used shall be considered as part of the dial),

(iv) 100 microcuries of promethium 147 per watch or 200 microcuries of promethium 147 per any other timepiece,

(v) 20 microcuries of promethium 147 per watch hand or 40 microcuries of promethium 147 per other timepiece hand,

(vi) 60 microcuries of promethium 147 per watch dial or 120 microcuries of promethium 147 per other timepiece dial (bezels when used shall be considered as part of the dial),

(vii) The levels of radiation from hands and dials containing promethium 147 will not exceed, when measured through 50 milligrams per square centimeter of absorber:

(a) For wrist watches, 0.1 millirad per hour at 10 centimeters from any surface,

(b) For pocket watches, 0.1 millirad per hour at 1 centimeter from any surface,

(c) For any other timepiece, 0.2 millirad per hour at 10 centimeters from any surface.

(2) Lock illuminators containing not more than 15 millicuries of tritium or not more than 2 millicuries of promethium 147 installed in automobile locks. The levels of radiation from each lock illuminator containing promethium 147 will not exceed 1 millirad per hour at 1

31 FR 5315

*§30.15 revised
32 F.R. 13920, Oct. 6, 1967

centimeter from any surface when measured through 50 milligrams per square centimeter of absorber.

(3) Balances of precision containing not more than 1 millicurie of tritium per balance or not more than 0.5 millicurie of tritium per balance part.[1]

(4) Automobile shift quadrants containing not more than 25 millicuries of tritium.

[2]*(5) Marine compasses containing not more than 750 millicuries of tritium gas and other marine navigational instruments containing not more than 250 millicuries of tritium gas.

(6) Thermostat dials and pointers containing not more than 25 millicuries of tritium per thermostat.

**(7) Glow lamps containing not more than 10 microcuries of tritium per lamp.

****(8) Spark gap tubes containing not more than 30 microcuries of promethium 147. The levels of radiation from each spark gap tube containing promethium 147 will not exceed 0.5 millirad per hour at 1 centimeter from any surface when measured through 7 milligrams per square centimeter of absorber.

(b) Any person who desires to apply tritium or promethium 147 to, or to incorporate tritium or promethium 147 into, the products exempted in paragraph (a) of this section, or who desires to import for sale or distribution such products containing tritium or promethium 147, should apply for a specific license, pursuant to § 32.14 of this chapter, which license states that the product may be distributed by the licensee to persons exempt from the regulations pursuant to paragraph (a) of this section.

31 FR 5315

[1] Export shipment of precision balances is subject to the licensing authority and regulations of the Department of Commerce. Issuance of an exemption by the Atomic Energy Commission for export of tritium contained in balances of precision or the parts thereof does not relieve any person from complying with the licensing requirements and regulations of the Department of Commerce.

** Added 31 FR 14349

*** Amended 32 FR 785

**** Added 32 FR 6433

[2]* **§ 30.16 Resins containing scandium 46 and designed for sand-consolidation in oil wells.**

Any person is exempt from the requirements for a license set forth in section 81 of the Act and from the regulations in Parts 20 and 30–36 of this chapter to the extent that such person receives, possesses, uses, transfers, exports, owns, or acquires synthetic plastic resins containing scandium 46 which are designed for sand-consolidation in oil wells, and which have been manufactured or imported for sale or distribution, in accordance with a specific license issued pursuant to § 32.17 of this chapter or equivalent regulations of an agreement State. The exemption in this section does not authorize the manufacture or import of any resins containing scandium 46.

* Added 32 FR 4241

LICENSES

§ 30.31 Types of licenses.

Licenses for byproduct material are of two types: General and specific. Specific licenses are issued to named persons upon applications filed pursuant to the regulations in this part and Parts 32–36. General licenses are effective without the filing of applications with the Commission or the issuance of licensing documents to particular persons.

30 FR 8185

§ 30.32 Applications for specific licenses.

(a) Applications for specific licenses should be filed on Form AEC–313, "Application for Byproduct Material License", with the Director, Division of Materials Licensing, U.S. Atomic Energy Commission, Washington, D.C., 20545. Applications may be filed in person at the Commission's offices at 1717 H Street NW., Washington, D.C.; at 4915 St. Elmo Avenue, Bethesda, Md.; or at Germantown, Md. Information contained in previous applications, statements or reports filed with the Commission may be incorporated by reference, provided that such references are clear and specific.

(b) The Commission may at any time after the filing of the original application, and before the expiration of the license, require further statements in order to enable the Commission to determine whether the application should be granted or denied or whether a license should be modified or revoked.

(c) Each application shall be signed by the applicant or licensee or a person duly authorized to act for and on his behalf.

(d) An application for license filed pursuant to the regulations in this part and Parts 32–36 will be considered also as an application for licenses authorizing other activities for which licenses are required by the Act, provided that the application specifies the additional activ-

ities for which licenses are requested and complies with regulations of the Commission as to applications for such licenses.

§ 30.33 General requirements for issuance of specific licenses.

(a) An application for a specific license will be approved if:

(1) The application is for a purpose authorized by the Act;

(2) The applicant's proposed equipment and facilities are adequate to protect health and minimize danger to life or property;

(3) The applicant is qualified by training and experience to use the material for the purpose requested in such manner as to protect health and minimize danger to life or property; and

(4) The applicant satisfies any special requirements contained in Parts 32–36.

(b) Upon a determination that an application meets the requirements of the Act, and the regulations of the Commission, the Commission will issue a specific license authorizing the possession and use of byproduct material (Form AEC 374, "Byproduct Material License").

§ 30.34 Terms and conditions of licenses.

(a) Each license issued pursuant to the regulations in this part and the regulations in Parts 31–36 shall be subject to all the provisions of the Act, now or hereafter in effect, and to all valid rules, regulations and orders of the Commission.

(b) No license issued or granted pursuant to the regulations in this part and Parts 31–36, nor any right under a license shall be transferred, assigned or in any manner disposed of, either voluntarily or involuntarily, directly or indirectly, through transfer of control of any license to any person, unless the Commission shall, after securing full information, find that the transfer is in accordance with the provisions of the Act and shall give its consent in writing.

(c) Each person licensed by the Commission pursuant to the regulations in this part and Parts 31–36 shall confine his possession and use of the byproduct material to the locations and purposes authorized in the license. Except as otherwise provided in the license, a license issued pursuant to the regulations in this part and Parts 31–36 shall carry with it the right to receive, acquire, own, possess and import byproduct material and to transfer such material to other licensees within the United States authorized to receive such material.

(d) Each license issued pursuant to the regulations in this part and Parts 31–36 shall be deemed to contain the provisions set forth in section 183b.–d., inclusive, of the Act, whether or not these provisions are expressly set forth in the license.

(e) The Commission may incorporate, in any license issued pursuant to the regulations in this part and Parts 31–36, at the time of issuance, or thereafter by appropriate rule, regulation or order, such additional requirements and conditions with respect to the licensee's receipt, possession, use and transfer of byproduct material as it deems appropriate or necessary in order to:

(1) Promote the common defense and security;

(2) Protect health or to minimize danger to life or property;

(3) Protect restricted data;

(4) Require such reports and the keeping of such records, and to provide for such inspections of activities under the license as may be necessary or appropriate to effectuate the purposes of the Act and regulations thereunder.

§ 30.35 References in licenses outstanding on effective date of recodification of this part.

References to sections of Parts 30 and 31 and to Parts 30 and 31 in licenses outstanding on the effective date of this recodification shall be deemed to be references to the sections of Parts 30–36 and to Parts 30–36 superseding those denoted in the outstanding licenses.

§ 30.36 Expiration of licenses.

Except as provided in § 30.37(b), each specific license shall expire at the end of the day, in the month and year stated therein.

§ 30.37 Applications for renewal of licenses.

(a) Applications for renewal of a specific license shall be filed in accordance with § 30.32.

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

§ 30.38 Applications for amendment of licenses.

Applications for amendment of a license shall be filed in accordance with § 30.32 and shall specify the respects in which the licensee desires his license to be amended and the grounds for such amendment.

§ 30.39 Commission action on applications to renew or amend.

In considering an application by a licensee to renew or amend his license the Commission will apply the applicable criteria set forth in § 30.33 and Parts 32–36 of this chapter.

Records, Inspections and Tests

§ 30.51 Records.

Each person who receives byproduct material pursuant to a license issued pursuant to the regulations in this part and Parts 31–36 shall keep records showing the receipt, transfer, export and disposal of such byproduct material.

§ 30.52 Inspections.

(a) Each licensee shall afford to the Commission at all reasonable times opportunity to inspect byproduct material and the premises and facilities wherein byproduct material is used or stored.

(b) Each licensee shall make available to the Commission for inspection, upon reasonable notice, records kept by him pursuant to the regulations in this chapter.

30 FR 8185

§ 30.53 Tests.

Each licensee shall perform, or permit the Commission to perform, such tests as the Commission deems appropriate or necessary for the administration of the regulations in this part and Parts 31–36, including tests of:

(a) Byproduct material;

(b) Facilities wherein byproduct material is utilized or stored;

(c) Radiation detection and monitoring instruments; and

(d) Other equipment and devices used in connection with the utilization or storage of byproduct material.

Enforcement

§ 30.61 Modification and revocation of licenses.

(a) The terms and conditions of each license issued pursuant to the regulations in this part and Parts 31–36 shall be subject to amendment, revision or modification by reason of amendments to the Act, or by reason of rules, regulations and orders issued in accordance with the terms of the Act.

(b) Any license may be revoked, suspended or modified, in whole or in part, for any material false statement in the application or any statement of fact required under section 182 of the Act, or because of conditions revealed by such application or statement of fact or any report, record or inspection or other means which would warrant the Commission to refuse to grant a license on an original application, or for violation of, or failure to observe any of the terms and provisions of the Act or of any rule, regulation or order of the Commission.

(c) Except in cases of willfulness or those in which the public health, interest or safety requires otherwise, no license shall be modified, suspended or revoked unless, prior to the institution of proceedings therefor, facts or conduct which may warrant such action shall have been called to the attention of the licensee in writing and the licensee shall have been accorded an opportunity to demonstrate or achieve compliance with all lawful requirements.

§ 30.62 Right to withhold or recall byproduct material.

The Commission may withhold, recall or order the withholding or recall of byproduct material from any licensee who is not equipped to observe or fails to observe such safety standards to protect health as may be established by the Commission, or who uses such materials in violation of law or regulation of the Commission, or in a manner other than as disclosed in the application therefor or approved by the Commission.

§ 30.63 Violations.

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 crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law.

SCHEDULES

§ 30.70 Schedule A—Exempt concentrations.

Element (atomic number)	Isotope	Column I Gas concentration uc/ml [1]	Column II Liquid and solid concentration uc/ml [2]
Antimony (51)	Sb 122		3×10^{-4}
	Sb 124		2×10^{-4}
	Sb 125		1×10^{-3}
Argon (18)	A 37	1×10^{-3}	
	A 41	4×10^{-7}	
Arsenic (33)	As 73		5×10^{-3}
	As 74		5×10^{-4}
	As 76		2×10^{-3}
	As 77		8×10^{-4}
Barium (56)	Ba 131		2×10^{-3}
	Ba 140		3×10^{-4}
Beryllium (4)	Be 7		2×10^{-2}
Bismuth (83)	Bi 206		4×10^{-4}
Bromine (35)	Br 82	4×10^{-7}	3×10^{-4}
Cadmium (48)	Cd 109		2×10^{-3}
	Cd 115m		3×10^{-4}
	Cd 115		3×10^{-4}
Calcium (20)	Ca 45		9×10^{-5}
	Ca 47		5×10^{-4}
Carbon (6)	C 14	1×10^{-6}	8×10^{-4}
Cerium (58)	Ce 141		9×10^{-4}
	Ce 143		4×10^{-4}
	Ce 144		1×10^{-4}
Cesium (55)	Cs 131		2×10^{-3}
	Cs 134m		6×10^{-3}
	Cs 134		9×10^{-5}
Chlorine (17)	Cl 38	9×10^{-7}	4×10^{-4}
Chromium (24)	Cr 51		2×10^{-3}
Cobalt (27)	Co 57		5×10^{-3}
	Co 58		1×10^{-4}
	Co 60		5×10^{-4}
Copper (29)	Cu 64		3×10^{-4}
Dysprosium (66)	Dy 165		4×10^{-3}
	Dy 166		4×10^{-4}
Erbium (68)	Er 169		9×10^{-4}
	Er 171		1×10^{-3}
Europium (63)	Eu 152 (T1/2=9.2 Hrs)		6×10^{-4}
	Eu 155		2×10^{-3}
Fluorine (9)	F 18	2×10^{-6}	8×10^{-5}
Gadolinium (64)	Gd 153		2×10^{-4}
	Gd 159		8×10^{-4}
Gallium (31)	Ga 72		4×10^{-4}
Germanium (32)	Ge 71		2×10^{-2}
Gold (79)	Au 196		2×10^{-3}
	Au 198		5×10^{-4}
	Au 199		2×10^{-3}
Hafnium (72)	Hf 181		7×10^{-4}
Hydrogen (1)	H 3	5×10^{-6}	3×10^{-1}
Indium (49)	In 113m		1×10^{-2}
	In 114m		2×10^{-4}
Iodine (53)	I 126	3×10^{-9}	2×10^{-4}
	I 131	3×10^{-9}	2×10^{-4}
	I 132	8×10^{-8}	6×10^{-4}
	I 133	1×10^{-8}	7×10^{-4}
	I 134	2×10^{-7}	1×10^{-3}
Iridium (77)	Ir 190		2×10^{-4}
	Ir 192		4×10^{-4}
	Ir 194		3×10^{-4}
Iron (26)	Fe 55		8×10^{-4}
	Fe 59		6×10^{-4}
Krypton (36)	Kr 85m	1×10^{-6}	
	Kr 85	3×10^{-6}	
Lanthanum (57)	La 140		2×10^{-4}
Lead (82)	Pb 203		4×10^{-3}
Lutetium (71)	Lu 177		1×10^{-3}
Manganese (25)	Mn 52		2×10^{-4}
	Mn 54		1×10^{-3}
	Mn 56		1×10^{-3}
Mercury (80)	Hg 197m		2×10^{-3}
	Hg 197		3×10^{-3}
	Hg 203		2×10^{-4}
Molybdenum (42)	Mo 99		2×10^{-3}
Neodymium (60)	Nd 147		6×10^{-4}
	Nd 149		3×10^{-3}
Nickel (28)	Ni 65		1×10^{-3}
Niobium (Columbium) (41)	Nb 95		1×10^{-3}
	Nb 97		9×10^{-3}
Osmium (76)	Os 185		7×10^{-4}
	Os 191m		3×10^{-2}
	Os 191		2×10^{-3}
	Os 193		6×10^{-4}
Palladium (46)	Pd 103		3×10^{-3}
	Pd 109		9×10^{-4}
Phosphorus (15)	P 32		2×10^{-4}
Platinum (78)	Pt 191		1×10^{-3}
	Pt 193m		1×10^{-2}
	Pt 197m		1×10^{-3}
	Pt 197		1×10^{-3}
Potassium (19)	K 42		3×10^{-4}
Praseodymium (59)	Pr 142		3×10^{-4}
	Pr 143		5×10^{-3}
Promethium (61)	Pm 147		2×10^{-3}
	Pm 149		4×10^{-4}
Rhenium (75)	Re 183		6×10^{-3}
	Re 186		9×10^{-4}
	Re 188		6×10^{-4}
Rhodium (45)	Rh 103m		1×10^{-1}
	Rh 105		1×10^{-3}
Rubidium (37)	Rb 86		7×10^{-4}
Ruthenium (44)	Ru 97		4×10^{-3}
	Ru 103		8×10^{-4}
	Ru 105		1×10^{-3}
	Ru 106		1×10^{-4}
Samarium (62)	Sm 153		8×10^{-4}
Scandium (21)	Sc 46		4×10^{-4}
	Sc 47		9×10^{-4}
	Sc 48		3×10^{-4}
Selenium (34)	Se 75		3×10^{-4}
Silicon (14)	Si 31		9×10^{-4}
Silver (47)	Ag 105		1×10^{-3}
	Ag 110m		3×10^{-4}
	Ag 111		4×10^{-4}
Sodium (11)	Na 24		2×10^{-4}
Strontium (38)	Sr 89		1×10^{-3}
	Sr 91		7×10^{-4}
	Sr 92		7×10^{-4}
Sulfur (16)	S 35	9×10^{-6}	6×10^{-4}
Tantalum (73)	Ta 182		4×10^{-4}
Technetium (43)	Tc 96m		1×10^{-1}
	Tc 96		1×10^{-3}
Tellurium (52)	Te 125m		2×10^{-3}
	Te 127m		6×10^{-4}
	Te 127		8×10^{-3}
	Te 129m		3×10^{-4}
	Te 131m		6×10^{-4}
	Te 132		3×10^{-4}
Terbium (65)	Tb 160		4×10^{-4}
Thallium (81)	Tl 200		4×10^{-4}
	Tl 201		3×10^{-3}
	Tl 202		1×10^{-3}
	Tl 204		1×10^{-3}
Thulium (69)	Tm 170		5×10^{-4}
	Tm 171		5×10^{-3}
Tin (50)	Sn 113		9×10^{-4}
	Sn 125		2×10^{-4}
Tungsten (Wolfram) (74)	W 181		4×10^{-3}
	W 187		7×10^{-4}
Vanadium (23)	V 48		3×10^{-4}
Xenon (54)	Xe 131m	4×10^{-6}	
	Xe 133	3×10^{-6}	
	Xe 135	1×10^{-6}	
Ytterbium (70)	Yb 175		1×10^{-3}
Yttrium (39)	Y 90		2×10^{-4}
	Y 91m		3×10^{-2}
	Y 91		3×10^{-4}
	Y 92		6×10^{-4}
	Y 93		3×10^{-4}
Zinc (30)	Zn 65		1×10^{-3}
	Zn 69m		7×10^{-4}
	Zn 69		2×10^{-2}
Zirconium (40)	Zr 93		6×10^{-4}
	Zr 97		2×10^{-4}
Beta and/or gamma emitting byproduct material not listed above with half-life less than 3 years.			1×10^{-4}

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

NOTE 2: For purposes of § 30.14 where there is involved a combination of isotopes, the limit for the combination should be derived as follows:

Determine for each isotope in the product the ratio between the concentration present in the product and the exempt concentration established in Schedule A for the specific isotope when not in combination. The sum of such ratios may not exceed "1" (i.e., unity).

Example:

$$\frac{\text{Concentration of Isotope A in Product}}{\text{Exempt concentration of Isotope A}} + \frac{\text{Concentration of Isotope B in Product}}{\text{Exempt concentration of Isotope B}} \leq 1$$

[1] Values are given only for those materials normally used as gases.

[2] uc/gm for solids.

CROSS REFERENCE TABLE

New section	Old section
30.1	30.1, 30.2
30.2	New
30.3	30.3
30.4	30.4
30.5	30.5
30.6	New
30.11	30.8
30.12	30.6
30.13	30.7
30.14	30.9, 30.32(f)
30.15	30.10
30.16	30.12
30.17	30.14
30.31	30.20
30.32	30.22
30.33	30.23, 30.31(a)
30.34	30.32(a)–(d), 30.31(b), 30.38
30.35	New
30.36	30.34
30.37	30.35
30.38	30.36
30.39	30.37
30.51	30.41
30.52	30.43
30.53	30.44
30.61	30.51
30.62	30.52
30.63	30.61
30.70	30.73

30 F.R. 8185

PART 30

RULES OF GENERAL APPLICABILITY TO LICENSING OF BYPRODUCT MATERIAL

PROPOSED RULE MAKING

32 FR 3995
32 FR 6099

FACILITY AND
MATERIALS LICENSES --
PROPOSED FEES

See Part 170, Proposed
Rule Making.

ADVANTAGES OF TRITIUM LUMINESCENT DEVICES

by
James W. Hitch

The purpose of this communication is to emphasize the advantages of luminescent devices using tritium and to document the very low radiation hazard associated with these devices.

These devices are composed of luminescent crystals commonly known as phosphors; such crystals are an essential part of television screens, fluorescent lights and luminescent watches and clocks. There are hundreds of different phosphors; however, the most generally used ones are zinc sulfide and cadmium sulfide. These are extremely pure crystals mixed with minute amounts of selected foreign atoms as activators. The wave length of emitted light is dependent on the amount and type of impurity added.

The well known luminous paint used on watch and clock dials consists of activated zinc sulfide energized by small amounts of radium sulfate. The alpha particles and, to a lesser extent, the beta particles from the radium produce light in the manner described below.

When incident radiation is absorbed by the crystals, some of the electrons are excited; that is, they absorb sufficient energy to transfer them to a higher energy level. Since this results in an unstable situation, they seek to fall back to their ground state and lose the excess energy in the process. This energy loss is released as heat; however, when a few parts per million of a foreign atom is used as an activator, such as copper introduced into the crystal, distortions are produced in the orderly

array of atoms which enable the excited electrons to occupy the elevated energy state for longer periods of time before falling back to the ground state. These distortions are called luminescent centers and they allow some of the absorbed energy to be emitted as light. Different colors throughout the spectrum can be used by selecting the appropriate activator. For instance, silver added to zinc sulfide will produce a blue light. Other additives such as copper will produce green, cadmium - yellow, or if one uses a cadmium sulfide, one is able to obtain a deep red light.

Unfortunately, the heavy, energetic alpha particles from radium and other alpha emitters damage the crystal structure of the phosphor and markedly shorten its expectant life. This disadvantage with radium is further augmented by the danger of the radium being ingested if accidentally released. Ingestion is most likely during manufacture of the compound and when it is being applied to watch and clock dials and other devices.

Beta particles, on the other hand, do not damage the phosphor crystals appreciably and, therefore, are able to produce much higher long-term brightness than is possible with radium. The attached table of beta emitters is helpful in selecting isotopes with the desirable characteristics for light sources. Some of the characteristics of radioactive materials that are most desirable for light sources are (1) absence of high energy gamma rays, (2) low radiotoxicity, (3) appreciably long half life, (4) absence of radioactive daughter products, and (5) low cost and ready availability. Strontium 90 is a favorable choice in every way except for

its high toxicity. To this end, the AEC's Office of Isotopes Development is sponsoring work to develop radioactive compounds which will be low in toxicity (biologically inert) and yet retain all desirable characteristics.

Krypton 85 is very suitable for use in light sources since it is a noble gas and is not absorbed in biological systems if accidentally ingested or inhaled. However, it does have a small amount of gamma radiation which restricts its use for some applications. Thus, Krypton 85 can be used very safely in markers that are not used adjacent to personnel for long periods.

Tritium is an excellent choice since its very low energy betas can be almost completely shielded within a luminescent paint. Recent work has led to tritiated compounds for luminescent devices that are essentially non-hazardous. Further, recent studies by Pinson and Langham indicate that biological conversion of tritium gas to tritiated water is about 50 times faster in rats than in man per unit body weight.[1] This could permit a higher body intake rate for tritium gas than previously considered permissible.

In the AEC's recent study of the use of tritium in clock and watch dials, it was concluded that tritium activated phosphors could be exempted from licensing since the tritium is chemically bound and cannot detach

---

1. Pinson, Ernest A., and Langham, Wright H., "Physiology and Toxicology of Tritium in Man," Journal of Applied Physiology, Vol. 10, Jan.-May 1957, pp. 108-126

itself from the insoluble and non-volatile plastic matrix unless the plastic is destroyed by fire or other violent chemical reactions.

Other equally effective means of binding tritium to the phosphor crystals have been developed. As the technology progresses, improved methods of binding undoubtedly will be developed.

Calculations indicate that there are approximately 2-4 million luminous dial watches sold in the United States each year. If the 25 millicuries of tritium contained in each of these watches is released into the environment on a yearly basis, the addition of tritium to the environment would be only 50,000 curies per year. It has been estimated that natural tritium production by cosmic rays is 2.5 million curies per year.[2] If we compare the dose rate to the body from tritiated dial watches, we find it is less than one/one hundred thousandths ($\frac{1}{100,000}$) of the dose rate from all natural background sources (about 150 millirad per year). Thus, the maximum possible addition to environmental exposure from the use of 25 millicuries of tritium on each of these timepieces would be less than one/five millionths ($\frac{1}{5,000,000}$) of the natural background rate of exposure--an entirely negligible amount by any reasonable standard of safety. The following is a quote from reference 2 above:

"Conclusions: The possible radiation exposures from tritium-dial timepieces are negligible compared to those from luminous

---

2. "Radiation Safety Evaluation for Tritium-Activated Dials in Luminous Watches and Clocks"; on file for reference at the AEC Public Document Room, 1717 H Street, N.W., Washington, D. C.

timepieces presently in use, although exposures from present luminous timepieces are relatively low. Thus, the use of tritium-dial timepieces would be safe and, moreover, would be expected to result in a reduction of radiation exposure to the population."

February 1961

ISOTOPES EMITTING BETA RAYS

Isotope	Half life (years)	Maximum beta energy	Gamma ray (per cent)	Toxicity	Remarks
Tritium	12	0.018 MeV	Nil	Low	Low energy; ideal for luminous paint
Promethium 147	2.6	0.23	Nil	Medium	Expensive and short half-life
Krypton 85	10	0.67	0.5 per cent of 0.5 MeV	Low	Inert gas, fission product, little hazard if liberated
Strontium 90	28	0.54 2.2	Nil	High	Ideal for light production, but very toxic
Thallium 204	4.1	0.76	Nil	Medium	Short half-life, low specific activity

Courtesy of Wilson and Hughes, Isotopes Division, AERE, Harwell

UNITED STATES RADIUM CORPORATION

Recommendations for Handling and Mixing "Undark" Tritium Luminous Compound.

1. Safe Handling:

Open and handle the Tritium Luminous Compound in well ventilated facilities. If possible, confine handling and mixing in one specific area. Avoid any spilling of the luminous compound in the working area.

2. Mixing:

Place a small quantity of the Luminous Compound in a mixing cup.
Do not mix more than you contemplate using at the time.
Add enough U.S.R.C. 6X Adhesive into mixing cup to wet the compound so that upon stirring a smooth but heavy paste is formed. A satisfactory mix is obtained at a ratio of 70% compound to 30% 6X adhesive.
Add U.S.R.C. 6X Thinner drop by drop with stirring until the compound reaches a consistency for painting with a red sable hair brush.
Judicious use of thinner is recommended.

3. Application:

After painting, air dry at room temperature from one to several hours.
Follow by a 1-½ hour oven bake at a temperature of 180°F.

Exercise sanitary precaution in handling and applying. Hands should be thoroughly cleansed after any operation involving Tritium Luminous Compound. Wearing of rubber surgical-type gloves is recommended.

RBC 6/63

UNITED STATES ATOMIC ENERGY COMMISSION

June 14, 1960

RADIATION SAFETY EVALUATION OF TRITIUM-ACTIVATED DIALS IN LUMINOUS WATCHES AND CLOCKS

The use of radium-activated paints on luminous watches and clocks dates back to the early part of this century. At present, about 125 million watches are in use in the United States, of which about 10-20 percent are luminous. In addition, there are about three-fourths as many luminous clocks as there are luminous watches.

Recently, substitutes for radium have been developed using other radioactive isotopes that have become available as byproducts of the atomic energy program. Some of these radioactive isotopes are considered to be safer than radium. One of these isotopes is tritium (H^3), which emits a very low energy beta particle and no gamma radiation.

The Atomic Energy Commission (AEC) has received requests from industry to allow the commercial distribution of tritium-activated luminous timepieces, without requiring the purchasers to obtain licenses from the AEC. Information has been submitted to the Commission demonstrating that safe and efficient luminous paints can be produced from tritium-activated phosphors.

The Commission finds that the proposed exemption from licensing procedures of tritium-activated watches and clocks, containing no more than 25 millicuries of tritium per timepiece and meeting the other specifications of the proposed Section 10 CFR 30.10, will not constitute an unreasonable risk to the common defense and security and to the health and safety of the public. Furthermore, under the conditions of the proposed amendment, the use of tritium in luminous timepieces would result in practically no radiation exposure to the public, whereas the use of radium has been estimated to give an average exposure of 10 milliroentgens per year to the reproductive organs of persons wearing luminous watches, and an average exposure to the whole population of 1 percent of that received from natural background radiation(1). Thus, the use of tritium in watches and clocks would not only be safe, but it would also tend to reduce the small amount of radiation received by the public from present luminous timepieces.

Below is a summary of the considerations in evaluating the safety of luminous timepieces containing tritium:

A. Characteristics of Tritium

Tritium (Hydrogen-3) is the only known radioisotope of Hydrogen. Tritium has a radioactive half-life of 12.3 years and disintegrates to Helium-3 by the emission of a beta particle with a maximum energy of 0.018 Mev. There is no gamma emission.

1. External Hazard -

Since the penetration of the maximum-energy beta particle from tritium is only 0.6 milligrams per square centimeter (less than the thickness of the outer layer of skin), there is no radiation hazard from tritium external to the body.

2. Internal Hazard -

Tritium gas in the elemental form does not present a significant internal hazard due to the fact that the amount of absorption is less than 0.1 percent by the lung tissue and negligible through the skin(2). However, experience has shown that varying amounts of tritium oxide are associated with the release of any form of tritium. Therefore, potential exposures are based on tritium oxide when working with tritium in any form. The oxides of tritium (HTO or T_2O) are readily absorbed into the body and become uniformly distributed throughout body fluids within 90 minutes (2)(3)(4)(5). The amount of tritium in the body (the "body burden") that will deliver 0.1 rem per week to the body tissues is 1 millicurie(6). The effective half-life in the body is only about 15 days.

The maximum permissible concentrations of HTO or T_2O for continuous intake are 2×10^{-6} microcuries per cc* for air and 0.03 microcuries per cc for water(6). The single permissible intake by inhalation of

*Value corrected by the NCRP.

soluble material to deliver 5 rems in 1 year to the total body is about 25 millicuries. About 860 microcuries of insoluble tritium inhaled into the lung at a single intake will deliver about 5 rems to the lung within 1 year.

The tritium-activated phosphors to be considered for exemption would be contained in an insoluble paint that is firmly bound to the face of the timepiece. An important advantage to the use of tritium is that tritium is an isotope of the chemical element hydrogen and it can thus be incorporated into the molecular structure of organic materials such as plastics. In this form, the tritium will not be easily detached from the insoluble and non-volatile plastic matrix unless the plastic is destroyed by fire or other violent chemical reaction. These chemical advantages are in addition to the advantage of the very low penetrating ability of the radiation from tritium.

The maximum quantity of tritium that could be applied to any timepiece under the proposed amendment is 25 millicuries. Based on relative scintillation efficiencies of tritium beta particles compared to radium alpha particles, 25 millicuries of tritium would give a luminosity equivalent to about 6 microcuries of radium. The average amount of radium on a luminous watch dial has been estimated[1,7] to be 1/4-1/5 microcurie.

Conditions of the proposed exemption would require that the tritium not be easily removable from the watch dial even when the watch is handled with its case removed. Under normal conditions of use, the tritium is bound to the phosphor and would present no hazard from inhalation. In the case of fire, it is possible that the entire 25 millicuries could be liberated in the form of tritium oxide (water). While it would be impossible for an individual to inhale or ingest any large portion of this activity, as an upper limit to the hazard from such an event, it may be noted that the intake of 25 millicuries of tritium into the body would result in an estimated whole body dose of about 5 rems. About half of this

dose would be received during the first two weeks following intake. Thus, the potential hazard is small either to repairmen handling timepieces or persons wearing watches containing tritium.

B. Relative Hazards of Tritium and Radium 226

1. Characteristics of Radium 226

Radium 226, the radioactive material now commonly used on watch dials, decays with a half-life of 1600 years. In addition to alpha and beta radiation, Radium 226 and its daughter products emit gamma radiation having an average photon energy of 0.78 Mev.

2. External Hazards

The radium gamma radiation is energetic enough to penetrate the watch crystal and expose the body of the wearer to low levels of radiation. Radium watches have been found to contain up to 2.2 microcuries of radium[7] with the average quantity being about 1/5 to 1/4 of a microcurie[1]. A watch containing 2.2 μc was found to read 8 milliroentgens per hour at the back of the watch[7]. The average watch would give doses about one-tenth as great as the 2.2 μc watch. Thus, a watch containing 0.22 μc of radium worn 16 hours per day would give a dose of about 90 millirem per week to the wrist or about 4.5 rem per year. This dose is received only in a small part of the forearm near the watch, but it may be compared to the maximum permissible limit of 75 rem per year to hands and forearms recommended for radiation workers[8].

The British Medical Research Council estimated that luminous watches and luminous clocks containing an average of 1/5 microcurie of radium increased the population dose to the gonads by 1 percent of natural background[1]. Dr. Haybittle notes that if watches containing the larger amounts of radium should become more popular with the public, then luminous watches would be second only to diagnostic radiology in the dose contributed to the gonads. Thus, under some conditions of use, radium

watches might produce genetically-significant exposures whereas the radiation dose from tritium-dial watches would be essentially zero.

3. Internal Hazards

Although it is very unlikely that anyone would ingest or inhale significant amounts of any radioactive material used on luminous timepieces, it is of interest to compare the relative internal hazards from radium and tritium. The permissible body burden of radium is 1/10 microcurie. The permissible radium concentrations(6) for continuous exposure are 10^{-7} microcuries per cc in water and 10^{-11} microcuries per cc in air. A single intake of 0.4 microcurie of soluble Radium 226 by inhalation will deliver about 5 rem to the bone within 1 year. A single intake by inhalation of 0.02 microcurie of insoluble Radium 226 will deliver a dose of 5 rem to the lung within 1 year.

Because of the well-known higher scintillation efficiencies of beta radiation compared to those of alpha radiation, about 6 microcuries of radium would be required to produce the same luminosity as 25 millicuries of tritium. The maximum internal dose received from 25 millicuries of tritium would be (a) a total dose of 150 rem to the lung delivered over several weeks from the inhalation of 25 millicuries of tritium in insoluble form and (b) about 5 rem to the whole body delivered over several weeks by 25 millicuries of tritium taken into the body in soluble form by inhalation or absorption. For comparison, the maximum doses from an amount of radium equivalent in luminous potential would be (a) a total dose of 1500 rem to the lung delivered over several years from the inhalation of 6 μc of radium in insoluble form, and (b) a total dose of about 2700 rem to the bone delivered over 70 years from the inhalation of 6 μc of radium in soluble form. From the above, it appears that the potential radiation exposure from tritium-activated luminous timepieces would be much less than the exposures (usually very small) possible from timepieces containing radium, which are now in use. The comparison of the characteristics of radium with tritium is summarized in Table I.

C. Possible Concentrations of Tritium in Storage Areas

In fires or other violent catastrophes, the hazards from tritium exposure would usually be negligible compared to other hazards. Any tritium released in the form of an organic plastic would be rapidly converted to water vapor and dispersed to the environment in negligible concentrations. Under normal storage conditions, the tritium incorporated in the molecular structure of an insoluble paint would be expected to remain on the watch. However, it is of interest to examine concentrations that might exist if the tritium were to diffuse from the watch at the maximum rate of 5 percent per year, allowed under the conditions of the proposed regulation.

There are few retail stores that stock more than 1,000 watches at a time. Assuming that 20 percent of the watches have luminous dials, it is of interest to examine the type of situation that would exist if 200 luminous watches, each containing the maximum quantity of 25 millicuries of tritium, were to remain stored in an airtight room with no ventilation for a one-month period. Assuming that the storage room is only 10 ft. x 10 ft. x 10 ft., or 2.8×10^7 cc in volume, and that each watch leaks tritium at the maximum rate of 5 percent per year, the tritium concentration at the end of one month would be 7×10^{-4} microcuries per cc. A person working in such an air concentration for one hour would breathe about 0.9 millicuries of tritium.

This amount of tritium in soluble form would deliver a whole body dose of about 180 millirem, most of it within several weeks; or as an insoluble dust it would deliver a dose of about 6 rem to the lung, most of it within several weeks. A ventilation rate of only one air change per hour would reduce the tritium concentration to about 10^{-6} microcuries per cc, which is within the maximum permissible concentration for continuous occupational exposure. Thus, even under the very conservative assumptions made above, the storage of tritium-dial watches would not present a significant hazard to the public.

D. Effects of Dispersal of Tritium to the Environment

The increase in background radiation dose, as well as the possible increase in genetic mutations from the incorporation of tritium in the chemical structure of reproductive cells, would be negligible even if the maximum amount of tritium on 2 million watches (i.e., 50,000 curies based on a maximum of 25 millicuries per watch) were dispersed to the environment yearly. (Information from the Department of Commerce and other sources indicates that about 2-4 million watches per year with luminous dials are presently sold in the United States. Considering probable increases within the next few years of the number of luminous dial watches distributed, the environmental exposure discussed here would still be negligible even if each timepiece contained the maximum of 25 millicuries of tritium.)

Although it is almost inconceivable that 50,000 curies of tritium would somehow be solubilized and dispersed to the environment yearly, this figure has been assumed as the upper limit of possibilities for the purposes of estimating environmental consequences. The upper limit of 50,000 curies per year is still small compared to a natural tritium production rate by cosmic rays of 2.5 million curies per year[9]. The dose rate to the body from naturally-produced tritium is less than one-hundred-thousandth of the dose rate of about 150 millirad per year from other background sources[10,11]. Thus, considering that the amount of tritium dispersed to the environment from watchdials would actually be much less than 50,000 curies per year, the addition to environmental radiation exposure from the proposed use of tritium on watchdials would be less (probably much less) than two ten-millionths of the rate of exposure from natural sources of radiation.

Since tritium is an isotope of hydrogen, the possibility exists that tritium could become incorporated into the chemical structure (DNA) of reproductive cells and thereby cause mutations as tritium atoms decay to helium atoms. Taking into consideration the natural ratio of 0.5×10^{-18} atoms of tritium per atom of hydrogen, the

natural tritium production rate, the amount of water in the world, the amount of DNA in a reproductive cell, and the percentage of hydrogen in DNA, an estimate was made of the maximum chance that mutations would occur in the world populations as a result of transmutations of tritium in DNA. The calculations show that the rate of mutations from all causes could be increased no more than two millionths of one percent by tritium removed from watchdials and incorporated in DNA, even if as much as 50,000 curies of tritium from watchdials were dispersed to the environment yearly. These calculations neglected many factors that cannot be estimated accurately, but which would probably reduce even this small increase in mutation rate many fold.

It is estimated(10) that about 2 percent of the total live births in the United States have tangible defects resulting from natural mutations. The National Academy of Sciences recommends(10) that the exposure from controlled sources of radiation should not exceed an average of 10 rems per generation up to age 30. This amount of radiation is estimated(10) to produce an increase of no more than 25 percent in the number of births with tangible genetic defects. For comparison, it is estimated that the total increase in the mutation rate, considering mutations from both radiation and transmutation phenomena, resulting from the dispersal of 50,000 curies of tritium per year to the environment would be less than two-ten-millionths of the natural mutation rate(10,11).

Thus, the above considerations show that any possible contribution to environmental sources of radiation from the use of tritium in timepieces would be extremely small.

E. Conclusions

The possible radiation exposures from tritium-dial timepieces are negligible compared to those from luminous timepieces presently in use, although exposures from present luminous timepieces are relatively low. Thus, the use of tritium-dial timepieces would be safe and, moreover, would be expected to result in a reduction of radiation exposure to the population.

TABLE I

COMPARISON OF RADIATION CHARACTERISTICS OF RADIUM- AND TRITIUM-ACTIVATED LUMINOUS TIMEPIECES

CHARACTERISTIC	TRITIUM	RADIUM
(1) Half-life	12.3 years	1620 years
(2) Radiations Emitted	Beta particles only--0.018 Mev maximum energy, 0.0055 Mev average	Alpha particles--24 Mev per Ra disintegration, in equilibrium with 5 alpha-emitting daughters; Beta particles--about 4 per Ra^{226} disintegration with maximum energies 0.65, 2.3, 0.017, and 1.17 Mev; Gamma Rays--about 2.29 photons per Ra^{226} disintegration, with energies ranging from 0.184--2.2 Mev., averaging 0.78 Mev
(3) Range of Radiation in Tissue	0.0006 cm-range of maximum energy beta particle in tissue	0.5 cm-range of maximum energy beta particle; 10 inches-average penetration of gamma rays, range is infinite
(4) External Dose Rate at 1 Foot from Watch	Negligible-low energy bremsstrahlung is absorbed in watch crystal	About 0.099 mr/hr at 1 foot per microcurie
(5) Maximum Permissible Continuous Body Burden (NBS Handbook 69)	1 millicurie	0.0001 millicurie
(6) Effective Half-Life in Total Body	15 days	1.6×10^4 days (practically all of the radium is retained in bone)

CHARACTERISTIC	TRITIUM	RADIUM
(7) Maximum Permissible Concentration in Air for Continuous Occupational Exposure	2×10^{-6} microcuries/cc (as HTO or T_2O); 4×10^{-4} µc/cc (as hydrogen gas)	10^{-11} microcuries/cc (in soluble form); 6×10^{-8} µc/cc (insoluble)
(8) Maximum Permissible Concentration in Water for Continuous Occupational Exposure	0.03 microcuries per cc (as water)	10^{-7} microcuries/cc (sol.); 3×10^{-4} µc/cc (insoluble)
(9) Dose from Single Intake by Inhalation	200 millirem to body per 1 millicurie soluble H^3; 6 rem to lung per 1 millicurie insoluble	450 rem to bone in 70 years per 1 microcurie soluble; 250 rem to lung per 1 microcurie insoluble

REFERENCES

1. "The Hazards to Man of Nuclear and Allied Radiations" British Medical Research Council, 1956 (Her Majesty's Stationery Office, London, England) P. 53.

2. Pinson, E. A. and Anderson, E. C. "The Absorption, Distribution and Excretion of Tritium in Man and Animals", AECU-937 (Nov. 24, 1950)

3. Pinson, E. A., "The Body Absorption, Distribution and Excretion of Tritium in Man and Animals", LA-1218 (March, 1951)

4. Pinson, E. A. "Absorption of Ingested Tritium Water and the Water Dilution Volume of Man", LA-1464 (June, 1952)

5. James N. P. Lawrence, "Estimation of Whole Body Dose (Rem) from Tritium in Body Water", LA-2163 (Feb. 1958)

6. "Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air and in Water for Occupational Exposure", NBS Handbook 69, June, 1959 (Supt. of Documents, Wash., D. C.)

7. J. L. Haybittle "Radiation Hazard from Luminous Watches", Nature, vol. 181, No. 4620, May 17, 1958

8. "Maximum Permissible Radiation Exposure to Man", Addendum to NBS Handbook 59, April 15, 1958 (Supt. of Documents, Wash., D. C.)

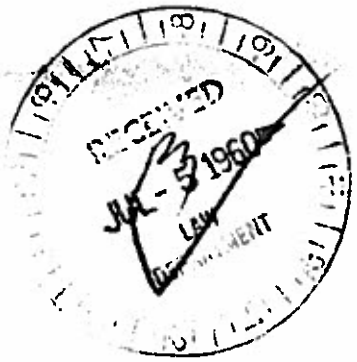
9. Calculated from data of S. Kaufmann and W. F. Libby, Phys. Rev. 93, 1337 (1954); H. Von Buttlar and W. F. Libby, J. Inorg and Nuc. Chem 1, 75 (1955)

10. "The Biological Effects of Atomic Radiation, National Academy of Sciences-National Research Council, Wash., D. C. (1956), P. 25.

11. "Report of the United Nations Scientific Committee on the Effects of Atomic Radiation", General Assembly Official Records: Thirteenth Session Supplement No. 17 (A/3838), New York, 1958 page 51

AEC

UNITED STATES
ATOMIC ENERGY COMMISSION
Washington 25, D. C.



No. C-124
Tel. HAzelwood 7-7831
Ext. 3446

FOR IMMEDIATE RELEASE
(Thursday, June 30, 1960)

AEC TO PERMIT USE OF TRITIUM ON LUMINOUS TIMEPIECES

The Atomic Energy Commission proposes to amend its regulations to allow the possession and use of luminous watches and clocks containing small amounts of Hydrogen 3 (tritium) in coatings of hands and dials.

The proposed change would permit the marketing of timepieces containing tritium-activated paint rather than the customary radium paint. The amendment would apply both to imported watches and clocks and to those manufactured in the United States.

Tritium is a radioactive material that emits only very low energy beta particles and has no penetrating gamma radiation. Its beta particles do not have enough energy to penetrate a watch crystal or the insensitive outer layer of the skin. The use of tritium on watches and clocks, therefore, would result in very limited radiation exposure to the user.

For this purpose, the tritium would be converted from its elemental state as a gas and incorporated into an organic chemical molecule which would become a constituent of the paint to be used on the luminous watches and clocks.

Radium is a naturally occurring radioactive material not under AEC jurisdiction. Luminous timepieces containing radium 226 -- which emits alpha, beta and penetrating gamma rays -- have been in general use since 1914.

(more)

The radiation intensities of radium-dial watches vary with differences in the amount of radium present. It has been estimated that an average radium-dial watch worn 16 hours a day gives an exposure of about 4.5 rems per year. This dose is received only in a small part of the forearm near the watch, but may be compared to a limit of 75 rems per year to hands and forearms permitted for radiation workers.

A rem (roentgen equivalent man) is a radiation dose of any ionizing radiation estimated to produce a biological effect equivalent to that produced by one roentgen of x-rays.

It also has been estimated that radium-dial watches and clocks increase the population dose to the gonads by about one per cent of natural background radiation.

Although in the typical radium-dial watch radiation levels are within limits considered acceptable, substitution of tritium for radium would serve to reduce the exposure of the general population to ionizing radiation.

The amount of tritium in the timepieces would be limited to 25 millicuries for each watch or clock. The amount of replacement parts would be limited to 5 millicuries of tritium on each luminous hand and 15 millicuries on each dial.

The Commission would license the preparation of luminous paints containing tritium and the application of these paints to clocks and watches by domestic firms. Luminous clocks and watches containing tritium, whether manufactured domestically or imported into the United States, could be distributed to users only if they met the specifications contained in the proposed amendment. These timepieces would be periodically sampled and inspected by the AEC.

An analysis of the characteristics of tritium and of the relative hazards of tritium and radium 226 on luminous watches and clocks has been prepared by the Commission staff and is available in the AEC's Public Document Room, 1717 H Street, N. W., Washington, D. C. Copies may also be obtained by writing to the Office of Public Information, Atomic Energy Commission, Washington 25, D. C. The paper is entitled "Radiation Safety Evaluation of Tritium-Activated Dials in Luminous Watches and Clocks."

(more)

Interested persons wishing to submit written comments or suggestions in connection with the proposed amendment to Title 10 Code of Federal Regulations Part 30 - Licensing of Byproduct Material - should send them to the Director, Division of Licensing and Regulation, U. S. Atomic Energy Commission, Washington 25, D. C. within 60 days after publication of notice in the Federal Register on July 2, 1960.

- 30 -

63060

AEC

UNITED STATES
ATOMIC ENERGY COMMISSION
Washington 25, D. C.

No. E-100
Tel. HAzelwood 7-7831
Ext. 3446

FOR IMMEDIATE RELEASE
(Friday, March 30, 1962)

AEC ESTABLISHES CRITERIA FOR INSTALLATION OF AUTOMOBILE LOCK ILLUMINATORS CONTAINING TRITIUM

The Atomic Energy Commission has approved an amendment to its regulations to establish criteria for the manufacture and installation of automobile lock illuminators, each containing up to 15 millicuries of radioactive tritium. The amendment also establishes criteria for the import of these lock illuminators.

Beta radiation from tritium acts upon phosphors to provide luminosity. There is no detectable external radiation from the lock illuminator.

The Commission has exempted these lock illuminators from its licensing requirements once the illuminators are installed in automobile locks. Manufacture of the luminescent ring containing tritium and its installation into automobile locks are subject to specific AEC licensing under the criteria being announced today.

The tritium used in the lock illuminator is in the form of paint completely sealed in plastic. There could be no dispersion of the material into the environment without destruction of the plastic ring into which it is incorporated. Since there is no detectable external radiation, the device containing up to 15 millicuries of tritium will not present a radiation hazard provided it is manufactured and installed according to specifications which AEC has established.

The Commission previously published for public comment a proposed amendment to its regulations establishing criteria for manufacture and installation of these lock illuminators. No comments were received. Several changes have been made in the interest of clarification. This amendment to AEC regulations 10 CFR Part 30, "Licensing of Byproduct Material," will be effective 30 days after publication in the Federal Register on March 31.

- 30 -

3/30/62

MAY 2 8 1965

MIL-T-46343(Ord)
21 May 1962

MILITARY SPECIFICATION

TRITIUM (HYDROGEN 3) SOLID FORM, SEALED SELF LUMINOUS SOURCES APPLICABLE FOR MILITARY MATERIEL: GENERAL SPECIFICATION FOR

1. SCOPE

1.1 This specification covers minimum requirements for sealed (encapsulated sources of tritium activated luminous material, including identification, marking and handling procedures. The sealed tritium activated luminous material shall hereinafter be referred to as "sealed material".

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids form a part of this specification to the extent specified herein.

STANDARDS

Military

MIL-STD-105	-Sampling Procedure and Tables for Inspection by Attributes
MIL-STD-130	-Identification Marking of U.S. Military Property
MIL-STD-202	-Test Methods for Electronic and Electrical Component Parts

(Copies of standards required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

PUBLICATIONS

Code of Federal Regulations (Atomic Energy) Title 10

(Application for copies should be addressed to Superintendent of Documents, Government Printing Office, Washington 25, D.C.)

FSC 1290

3. REQUIREMENTS

3.1 Qualification of manufacturer.- Manufacturers or producers shall not submit any materiel containing tritium activated luminous material until a specified license has been obtained from the Atomic Energy Commission as prescribed in the Code of Federal Regulations (Atomic Energy) Title 10 - Part 30.

3.2 Identification, license and disposition.- When the sealed material is used with military materiel or equipment, the identification, license number, and disposition for disposal shall be stamped or otherwise marked by decal, molding or other approved means to the materiel or equipment in the immediate area of the sealed luminous materiel. In addition, the month and year of manufacture shall appear together with the radiation caution symbol of any color, as specified by the contracting officer.

3.3 Material.- The luminous material shall consist of a smooth homogenous mixture consisting of essentially thinner, a solid containing phosphor, and a tritiated binder. The tritium shall be chemically combined with the binder. The amount of tritium (Hydrogen 3) used to obtain the desired brightness shall not exceed the number of millicuries as required by detailed procedures, drawings and specifications. The luminous material shall be used within sixty days of its formulation. The material used to encapsulate and seal the luminous material shall be transparent and capable of meeting all requirements herein specified.

3.4 Luminous sealed sources.- Luminous sealed sources made with radioactive luminous compounds shall be in accordance with Government approved drawings. The fluorescent color of the luminous compound shall conform to Government approved detailed drawings and specification requirements. When the compound is applied to a surface the initial brightness of the luminous sector shall be not less than the number of effective microlamberts specified on the Government approved drawings.

3.5 Contamination.- All exposed surfaces of the sealed material shall be wiped with high wet strength filter paper. The beta radioactivity accumulated on the filter paper shall at no time exceed 0.05 microcurie.

3.6 Storage temperature.- The sealed tritium activated material shall be exposed and thermally stabilized for a period of two hours at atmospheric pressure at an ambient temperature of minus eighty degrees Fahrenheit, and for a period of two hours at atmospheric pressure at an ambient temperature of plus one hundred sixty degrees Fahrenheit. Subsequent to exposure at these temperatures, the sealed material shall show no evidence of damage in any form to the luminous area and shall be capable of meeting the requirements of 3.5.

3.7 Altitude.- Sealed material which has been subjected to the requirements of 3.6 shall be exposed and thermally stabilized at an ambient temperature of minus sixty-five degrees Fahrenheit for a period of four hours at a pressure of eighty three millimeters of mercury, absolute. The temperature shall then be raised over a period of six hours to plus eighty six degrees Fahrenheit for a period of four hours at a pressure of one hundred thirty eight millimeters of mercury, absolute. Subsequent to which the temperature shall be reduced to plus

sixty eight degrees Fahrenheit at a pressure of eighty three millimeters of mercury, absolute and maintained for a period of four hours. Subsequent to meeting this requirement the sealed material shall show no evidence of damage in any form to the luminous area and shall be capable of meeting the requirements of 3.5.

3.8 Vibration.- The sealed material shall be subjected to vibration at a constant acceleration of 2.5 gravitational units for three minutes at each of the four most severe resonant frequencies. The four most severe resonant frequencies shall be determined by proper instrumentation during exposure to two vibratory cycles of fifteen minutes duration each over the frequency range of 5 to 500 cycles per second. Subsequent to vibration the requirements of 3.5 shall be met.

3.9 Shock.- The sealed material shall be subjected to three 150 G shocks, in each of three mutually perpendicular directions. Subsequent to the three shocks the sealed material shall show no evidence of damage in any form to the luminous area and shall be capable of meeting the requirements of 3.5.

3.10 Solubility.- Subsequent to being subjected to the requirements of 3.6, 3.7, 3.8 and 3.9, the sealed material containing tritium shall be submerged in water, the ambient temperature of which is between plus 60 to 90 degrees Fahrenheit, for a period of twenty-four hours. Subsequent to the water submersion not more than 0.05 microcurie of the luminous compound shall be dissolved in the water.

3.11 Workmanship.- Workmanship shall be of the highest grade throughout and in accordance with best laboratory and commercial practices for the manufacture, application and sealing of tritium material. All finishes shall be free from flaking or chipping of the luminous material or failure of the overlap seal or other physical defects that would tend to release or disseminate the luminous material.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibilities.- The supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to the Government. Inspection records of the examination and tests shall be kept complete and available to the Government as specified in the contract or order. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Sampling.- Sampling shall be in accordance with Standard MIL-STD-105, unless otherwise specified.

4.3 Material.- The luminous tritium activated material shall be inspected by laboratory methods to determine that the processes and homogeniety of the materials and binder and the transparency of the encapsulating material is in compliance with 3.3 and the specified drawings and specifications.

4.4 Identification license and disposition.- Sealed material shall not be submitted for final acceptance inspection without proof of licensing in compliance with 3.2. Items containing tritium activated luminous material shall be visually inspected to ascertain that the specified markings are in the immediate area of the luminous material in compliance with 3.3 and comply with regulations governing the identification and marking of tritium activated material as stated in 3.2.

4.5 Luminous sealed sources.- Sealed material containing radioactive luminous compounds shall be tested with equipment capable of determining the brightness in effective microlamberts as specified in the detailed specification or drawings in compliance with 3.4.

4.6 Contamination test.- Subsequent to each of the tests in 4.7 to 4.10 inclusive, all exposed surfaces of the sealed material shall be thoroughly wiped with a piece of filter paper of high wet strength and absorption capacity, moistened with a solution which will not attack the material of which the sealed source is made and which, under the conditions of this test, has been demonstrated to be effective in removing the radioisotope involved. The paper shall be allowed to dry then the amount of tritium on the paper shall be determined by a testing device that has been calibrated to measure the accumulated beta radioactivity in microcuries, in compliance with 3.5.

4.7 Temperature test.- The sealed material shall be placed in a test chamber and subjected to the extreme temperatures and required time limit specified to determine compliance with 3.6. At the conclusion of this test, it shall be visually inspected for any damage to the luminous area and shall then be subjected to the test of 4.6.

4.8 Altitude test.- The sealed material shall be placed in a test chamber and thermally stabilized at the specified temperatures and pressures for the required length of time to determine compliance with 3.7. At the conclusion of this test the sealed material shall be visually inspected for any damage to the luminous area and shall then be subjected to the test of 4.6.

4.9 Vibration.- The sealed material shall be secured on a vibration test stand and vibrated in accordance with the requirements of 3.8. Subsequent to vibration the item shall be subjected to a visual and tactile examination for damage and shall then be subjected to the test of 4.6.

4.10 Shock test.- The sealed material shall be shock tested in accordance with Method 202 of Standard MIL-STD-202. Subsequent to the shock test the sealed material shall be inspected for damage to the luminous area to determine compliance with 3.9, and the item shall then be subjected to the test of 4.6.

4.11 Solubility test.- When testing sealed material to determine solubility in compliance with 3.10 it shall be immersed in water at the specified temperature for the required time. After the water is evaporated, the residue shall then be measured for the microcurie content which shall not exceed the amount specified in 3.10. This shall be the final test performed on the sealed material.

4.12 Workmanship.- All finishes shall be inspected to ascertain that there is freedom from flaking or chipping of the luminous material, or failure of the seal to overlap the material which would tend to release or disseminate the luminous material.

5. PREPARATION FOR DELIVERY

5.1 Packaging, packing and marking.- Packaging, packing and marking shall be in accordance with requirements furnished by the contracting officer in connection with the contract and shall specify details for handling, packaging, packing and storage of material containing tritium (hydrogen 3).

5.2 Identification markings.- Identification markings for shipment and storage of individual items or bulk shipments shall show the following as permanent markings.

(a) Radiation Caution Symbol
(b) Atomic Energy Commission License Number
(c) Contains Mc of Radioactive H^3
(d) If Found Return to Military Authority

6. NOTES

6.1 This general specification is intended to establish the basic safety requirements and tests required of licensed producers of tritium encapsulated sealed self luminous material utilized by agencies within the Department of Defense.

6.2 For informational purposes and guidance, Atomic Energy Commission announcement "RC-13 Sealed Sources Containing Beta and/or Gamma-Emitting Radioistotopes", may be used for reference.

NOTICE: When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Custodian:

Army-Ord

Preparing activity:

Army-Ord

Copy to [redacted], L/821, 6-7-65

GPO 905888