252474 RS
030-03996

LAW ENGINEERING

GEOTECHNICAL, ENVIRONMENTAL & CONSTRUCTION MATERIALS CONSULTANTS

October 17, 1988 88-10-19 A9:51

U.S. Nuclear Regulatory Commission, Region 2
Nuclear Materials Safety Section
101 Marietta Street, Suite 2900
Atlanta, GA 30323

Attention: Ms Carol A. Connell

Subject: NRC License Number 10-00346-03
Request for Amendment to License

Dear Ms Connell:

Law Engineering requests that our license number 10-00346-03 be amended to add two Amersham model exposure devices. This amendment will require that items 6, 7, 8 and 9 of the Materials license be amended to include the exposure devices shown in attachment #1 to this letter.

Enclosed with this request are two copies of our Radiographic Manual dated October 1988. This revised manual contains additional operations and maintenance procedures for the Amersham exposure devices. For your convenience, all revisions to the Radiographic Manual are copied on pink sheets. Upon approval, the revised manual will be issued to our staff, but revisions will not be shown on pink paper.

A check in the amount of $230 is enclosed as payment for the processing fee for this amendment. Your prompt review of this amendment request will be appreciated. If you have any questions concerning this request, please feel free to contact me at 404/396-8000.

Very truly yours,

George F. Miller

George F. Miller, P.E.
By-Product Materials License Coordinator

enclosures

Log Oct-6-11
Remitter
Check No. 05628
$230
30
Rec'd 10/18/88
10/20/88 Mesa

OFFICIAL COPY

8911290381 881017
REG2 LIC30
10-00346-03 PDR

1000 ABERNATHY ROAD, N.E.
POST OFFICE BOX 888013
ATLANTA, GEORGIA 30356-0013
404-396-8000

ATTACHMENT #1
AMENDMENT TO LICENSE NO. 10-00346-03
OCTOBER 1988

ISOTOPE	MANU. AND MODEL # OF SOURCE ASSEMBLIES	MAXIMUM ACTIVITY PER SOURCE	MANU. AND MODEL # OF EXP. DEVICES	MANU. AND MODEL # OF SOURCE CHANGERS
G. Iridium 192	Amersham Industries A-424-9	100 curies	Amersham Industries 660	Amersham Industries 650 or 50034
H. Cobalt 60	Amersham Industries A-424-14	100 curies	Amersham Industries 680	Amersham Industries 771

RADIOGRAPHIC MANUAL

OCTOBER 1988

TABLE OF CONTENTS

SECTION I

AGREEMENT STATES REGULATIONS

[APPLICABLE AGREEMENT STATES REGULATIONS

TO BE INSERTED HERE]

SECTION II

NRC PART 19, 20, & 34

PART 19

NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS; INSPECTIONS

Authority: Secs. 53, 63, 81, 103, 104, 161, 68 Stat. 930, 933, 935, 936, 937, 948, 953, as amended, sec. 201, 88 Stat. 1242, as amended (42 U.S.C. 2073, 2093, 2111, 2133, 2134, 2201, 5841); sec. 202, 88 Stat. 1244, as amended by Pub. L. 93-438, 88 Stat. 1243 (42 U.S.C. 5842); Pub. L. 95-601, sec. 10, 92 Stat. 2951 (42 U.S.C. 5851).

For the purposes of sec. 223, 68 Stat. 958, as amended (42 U.S.C. 2273), §§ 19.11(a), (3), (4), and (c) and 19.13 are issued under sec. 161b, 68 Stat. 948, as amended (42 U.S.C. 2201(b)) and §§ 19.12 and 19.14(a) are issued under sec. 161o, 68 Stat. 950, as amended (42 U.S.C. 2201(o)).

§ 19.1 Purpose.

The regulations in this part establish requirements for notices, instructions, and reports by licensees to individuals participating in licensed activities, and options available to such individuals in connection with Commission inspections of licensees to ascertain compliance with the provisions of the Atomic Energy Act of 1954, as amended, Title II of the Energy Reorganization Act of 1974, and regulations, orders, and licenses thereunder regarding radiological working conditions.

§ 19.2 Scope.

The regulations in this part apply to all persons who receive, possess, use, or transfer material licensed by the Nuclear Regulatory Commission pursuant to the regulations in Parts 30 through 35, 39, 40, 60, 61, 70 or 72 of this chapter, including persons licensed to operate a production or utilization facility pursuant to Part 50 of this chapter and persons licensed to possess power reactor spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to Part 72 of this chapter.

§ 19.3 Definitions.

As used in this part:

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

(b) "Commission" means the United States Nuclear Regulatory Commission;

(c) "Worker" means an individual engaged in activities licensed by the Commission and controlled by a licensee, but does not include the licensee.

(d) "Licensee" means a licensee issued under the regulations in Parts 30 through 35, 39, 40, 60, 61, 70 or 72 of this chapter, including licensees to operate a production or utilization facility pursuant to Part 50 of this chapter and licensees to possess power reactor spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to Part 72 of this chapter. "Licensee" means the holder of such a license.

(e) "Restricted area" means any area access to which is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. "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.

§ 19.4 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.

19.5 Communications.

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

§ 19.6 Information collection requirements: OMB approval.

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). OMB has approved the information collection requirements contained in this part under control number 3150-0044.

(b) The approved information collection requirements contained in this part appear in § 19.13.

§ 19.11 Posting of notices to workers.

(a) Each licensee shall post current copies of the following documents: (1) The regulations in this part and in Part 20 of this chapter; (2) the license, license conditions, or documents incorporated into a license by reference, and amendments thereto; (3) the operating procedures applicable to licensed activities; (4) any notice of violation involving radiological working conditions, proposed imposition of civil penalty, or order issued pursuant to Subpart B of Part 2 of this chapter, and any response from the licensee.

(b) If posting of a document specified in paragraph (a) (1), (2) or (3) of this section is not practicable, the licensee may post a notice which describes the document and states where it may be examined.

(c) Each licensee and applicant shall post Form NRC-3, (Revision 8-83 or later) "Notice to Employees," as required by Parts 21, 30, 40, 61, 70, 72, and 150 of this chapter.

Note: Copies of Form NRC-3 may be obtained by writing to the Director of the appropriate U.S. Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix "D", Part 20 of this chapter, or the Director, Office of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

(d) Documents, notices, or forms posted pursuant to this section shall appear in a sufficient number of places to permit individuals engaged in licensed activities to observe them on the way to or from any particular licensed activity location to which the document applies, shall be conspicuous, and shall be replaced if defaced or altered.

(e) Commission documents posted pursuant to paragraph (a)(4) of this section shall be posted within 2 working days after receipt of the documents from the Commission; the licensee's response, if any, shall be posted within 2 working days after dispatch by the licensee. Such documents shall remain posted for a minimum of 2 working days or until action correcting the violation has been completed, whichever is later.

§ 19.12 Instructions to workers.

All individuals working in or frequenting any portion of a restricted area shall be kept informed of the storage, transfer, or use of radioactive materials or of radiation in such portions of the restricted area; shall be instructed in the health protection problems associated

PART 19 • NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS; INSPECTIONS

with exposure to such radioactive materials or radiation, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed; shall be instructed in, and instructed to observe, to the extent within the worker's control, the applicable provisions of Commission regulations and licenses for the protection of personnel from exposures to radiation or radioactive materials occurring in such areas; shall be instructed, of their responsibility to report promptly to the licensee any condition which may lead to or cause a violation of Commission regulations and licenses or unnecessary exposure to radiation or to radioactive material; shall be instructed in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation or radioactive material; and shall be advised as to the radiation exposure reports which workers may request pursuant to § 19.13. The extent of these instructions shall be commensurate with potential radiological health protection problems in the restricted area.

§ 19.13 Notifications and reports to individuals.

(a) Radiation exposure data for an individual, and the results of any measurements, analyses, and calculations of radioactive material deposited or retained in the body of an individual, shall be reported to the individual as specified in this section. The information reported shall include data and results obtained pursuant to Commission regulations, orders or license conditions, as shown in records maintained by the licensee pursuant to Commission regulations. Each notification and report shall: be in writing; include appropriate identifying data such as the name of the licensee, the name of the individual, the individual's social security number; include the individual's exposure information; and contain the following statement:

This report is furnished to you under the provisions of the Nuclear Regulatory Commission regulations 10 CFR Part 19. You should preserve this report for further reference.

(b) At the request of any worker, each licensee shall advise such worker annually of the worker's exposure to radiation or radioactive material as shown in records maintained by the licensee pursuant to § 20.401(a) and (c).

(c) At the request of a worker formerly engaged in licensed activities controlled by the licensee, each licensee shall furnish to the worker a report of the worker's exposure to radiation or radioactive material. Such report shall be furnished within 30 days from the time the request is made, or within 30 days after the exposure of the individual has been determined by the licensee, whichever is later; shall cover, within the period of time specified in the request, each calendar quarter in which the worker's activities involved exposure to radiation from radioactive materials licensed by the Commission; and shall include the dates and locations of licensed activities in which the worker participated during this period.

(d) When a licensee is required pursuant to § 20.408 or § 20.409 of this chapter to report to the Commission any exposure of an individual to radiation or radioactive material the licensee shall also provide the individual a report on his exposure data included therein. Such report shall be transmitted at a time not later than the transmittal to the Commission.

(e) At the request of a worker who is terminating employment in a given calendar quarter with the licensee in work involving radiation dose, or of a worker who, while employed by another person, is terminating assignment to work involving radiation dose in the licensee's facility in that calendar quarter, each licensee shall provide to each such worker, or to the worker's designee, at termination, a written report regarding the radiation dose received by that worker from operations of the licensee during that specifically identified calendar quarter or fraction thereof, or provide a written estimate of that dose if the finally determined personnel monitoring results are not available at that time. Estimated doses shall be clearly indicated as such.

§ 19.14 Presence of representatives of licensees and workers during inspection.

(a) Each licensee shall afford to the Commission at all reasonable times opportunity to inspect materials, activities, facilities, premises, and records pursuant to the regulations in this chapter.

(b) During an inspection, Commission inspectors may consult privately with workers as specified in § 19.18. The licensee or licensee's representative may accompany Commission inspectors during other phases of an inspection.

(c) If, at the time of inspection, an individual has been authorized by the workers to represent them during Commission inspections, the licensee shall notify the inspectors of such authorization and shall give the workers' representative an opportunity to accompany the inspectors during the inspection of physical working conditions.

(d) Each workers' representative shall be routinely engaged in licensed activities under control of the licensee and shall have received instructions as specified in § 19.12.

(e) Different representatives of licensees and workers may accompany the inspectors during different phases of an inspection if there is no resulting interference with the conduct of the inspection. However, only one workers' representative at a time may accompany the inspectors.

(f) With the approval of the licensee and the workers' representative an individual who is not routinely engaged in licensed activities under control of the licensee, for example, a consultant to the licensee or to the workers' representative, shall be afforded the opportunity to accompany Commission inspectors during the inspection of physical working conditions.

(g) Notwithstanding the other provisions of this section, Commission inspectors are authorized to refuse to permit accompaniment by any individual who deliberately interferes with a fair and orderly inspection. With regard to areas containing information classified by an agency of the U.S. Government in the interest of national security, an individual who accompanies an inspector may have access to such information only if authorized to do so. With regard to any area containing proprietary information, the workers' representative for that area shall be an individual previously authorized by the licensee to enter that area.

§ 19.15 Consultation with workers during inspections.

(a) Commission inspectors may consult privately with workers concerning matters of occupational radiation protection and other matters related to applicable provisions of Commission regulations and licenses to the extent the inspectors deem necessary for the conduct of an effective and thorough inspection.

(b) During the course of an inspection any worker may bring privately to the attention of the inspector, either orally or in writing, any past or present condition which he has reason to believe may have contributed to or caused any violation of the Act, the regulations in this chapter, or license condition, or any unnecessary exposure of an individual to radiation from licensed radioactive material under the licensee's control. Any such notice in writing shall comply with the requirements of § 19.16(a).

(c) The provisions of paragraph (b) of this section shall not be interpreted as authorization to disregard instructions pursuant to § 19.12.

§ 19.16 Requests by workers for inspections.

(a) Any worker or representative of workers who believes that a violation of the Act, the regulations in this chapter, or license conditions exists or has occurred in licensee activities with regard to radiological working conditions in which the worker is engaged, may request an inspection by giving notice of the alleged violation to the Director of Inspection and Enforcement, or the Director of the appropriate Commission Regional Office, or to Commission inspectors. Any such notice shall be in writing, shall set forth the specific grounds for the notice, and shall be signed by the worker or representative of workers. A copy shall be provided the licensee by the Director of Inspection and Enforcement, Regional Office Director, or the inspector no later than at the time of inspection except that, upon the request of the worker giving such notice, his name and the name of individuals referred to therein shall not appear in such copy or on any record published, released, or made available by the Commission, except for good cause shown.

(b) If, upon receipt of such notice, the Director of Inspection and Enforcement or Regional Office Director determines that the complaint meets the requirements set forth in paragraph (a) of this section, and that there are reasonable grounds to believe that the alleged violation exists or has occurred, he shall cause an inspection to be made as soon as practicable, to determine if such alleged violation exists or has occurred. Inspections pur-

person to this section need not be limited to persons referred to in the complaint.

§ 19.17 Inspections not warranted; informal review.

(a) If the Director of Inspection and Enforcement or of the appropriate Regional Office determines, with respect to a complaint under § 19.16, that an inspection is not warranted because there are no reasonable grounds to believe that a violation exists or has occurred, he shall notify the complainant in writing of such determination. The complainant may obtain review of such determination by submitting a written statement of position with the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, who will provide the licensee with a copy of such statement by certified mail, enclosing, at the request of the complainant, the name of the complainant. The licensee may submit an opposing written statement of position with the Executive Director for Operations who will provide the complainant with a copy of such statement by certified mail. Upon the request of the complainant, the Executive Director for Operations, or his designee, may hold an informal conference in which the complainant and the licensee may orally present their views. An informal conference may also be held at the request of the licensee, but disclosure of the identity of the complainant will be made only following receipt of written authorization from the complainant. After considering all written and oral views presented, the Executive Director for Operations shall affirm, modify, or reverse the determination of the Director of Inspection and Enforcement or of the appropriate Regional Office and furnish the complainant and the licensee a written notification of his decision and the reasons therefor.

(b) If the Director of Inspection and Enforcement or of the appropriate Regional Office determines that an inspection is not warranted because the requirements of § 19.16(a) have not been met, he shall notify the complainant in writing of such determination. Such determination shall be without prejudice to the filing of a new complaint meeting the requirements of § 19.16(a).

§ 19.18 Employee protection.

Employment discrimination by a licensee or a contractor or subcontractor of a licensee against an employee for engaging in protected activities under this part or Parts 50, 60, 70, 72, or 150 of this chapter is prohibited.

§ 19.20 Violations.

An injunction or other court order may be obtained prohibiting any violation of any provision of the Act or Title II of the Energy Reorganization Act of 1974, or any regulation or order issued thereunder.

A court order may be obtained for the payment of a civil penalty imposed pursuant to section 234 of the Act for violation of sections 53, 57, 62, 63, 81, 82, 161, 183, 184, 187, or 189 of the Act or any rule, regulation, or order issued thereunder, or any term, condition or limitation of any license issued thereunder, or for any violation for which a license may be revoked under section 186 of the Act. Any person who willfully violates any provision of the Act or any regulation or order issued thereunder may be guilty of a crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law.

§ 19.31 Application for exemptions.

The Commission may, upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

§ 19.32 Discrimination prohibited.

No person shall on the ground of sex be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity licensed by the Nuclear Regulatory Commission. This provision will be enforced through agency provisions and rules similar to those already established, with respect to racial and other discrimination, under title VI of the Civil Rights Act of 1964. This remedy is not exclusive, however, and will not prejudice or cut off any other legal remedies available to a discriminatee.

PART 20

STANDARDS FOR PROTECTION AGAINST RADIATION

PART 20—STANDARDS FOR PROTECTION AGAINST RADIATION

Authority: Secs. 53, 63, 65, 81, 103, 104, 161, 68 Stat. 930, 933, 935, 936, 937, 948, as amended, (42 U.S.C. 2073, 2093, 2095, 2111, 2133, 2134, 2201); sec. 201, as amended, 202, 204, Pub. L. 93-438, 88 Stat. 1242, 1244, 1245, Pub. L. 95-601, 92 Stat. 2951 (42 U.S.C. 5841, 5842, 5846).

For the purposes of sec. 223, 68 Stat. 958, as amended, (42 U.S.C. 2273), §§ 20.101, 20.102, 20.103(a) (b), and (f), 20.104 (a) and (b), 20.105(b), 20.106(a), 20.201, 20.202(a), 20.203, 20.205, 20.207, 20.301, 20.302, 20.304 and 20.305 are issued under sec. 161b, 68 Stat. 948, as amended, (42 U.S.C. 2201(b)) and §§ 20.103, 20.105(c), 20.401–20.407, 20.409(b) and 20.410 are issued under sec. 161o, 68 Stat. 950, as amended, (42 U.S.C. 2201(o)).

GENERAL PROVISIONS

§ 20.1 Purpose.

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

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

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

§ 20.2 Scope.

The regulations in this part apply to all persons who receive, possess, use, or transfer material licensed pursuant to the regulations in Parts 30 through 35, 40, 60, 61, 70, or 72 of this chapter, including persons licensed to operate a production or utilization facility pursuant to Part 50 of this chapter and persons licensed to possess power reactor spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to Part 72 of this chapter.

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

PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

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

(6) "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;

(7) "Individual" means any human being.

(8) "Licensed material" means source material, special nuclear material, or by-product material received, possessed, used, or transferred 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 Parts 30 through 36, 40, 50, 61, 70 or 72 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: (i) Any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency other than the Commission or the Department (except that the Department shall be considered a person within the meaning of the regulations in this part to the extent that its facilities and activities are subject to the licensing and related regulatory authority of the Commission pursuant to section 202 of the Energy Reorganization Act of 1974 (88 Stat. 1244)), any State, any foreign government or nation or any political subdivision of any such government or nation, or other entity; and (ii) 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 for purposes of protection of individuals from exposure to radiation and radioactive materials. "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: (i) Uranium or thorium, or any combination thereof, in any physical or chemical form or (ii) ores which contain by weight one-twentieth of one percent (0.05%) or more of (a) uranium, (b) thorium or (c) any combination thereof. Source material does not include special nuclear material.

(16) "Special nuclear material" means: (i) 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 (ii) any material artificially enriched by any of the foregoing but does not include source material;

(17) "Unrestricted area" means any area access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters;

(18) "Department" means the Department of Energy established by the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565, 42 U.S.C. 7101 *et seq.*) to the extent that the Department, or its duly authorized representatives, exercises functions formerly vested in the U.S. Atomic Energy Commission, its Chairman, members, officers and components and transferred to the U.S. Energy Research and Development Administration and to the Administrator thereof pursuant to sections 104 (b), (c) and (d) of the Energy Reorganization Act of 1974 (Pub. L. 93-438, 88 Stat. 1233 at 1237, 42 U.S.C. 5814) and retransferred to the Secretary of Energy pursuant to section 301(a) of the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 568 at 577-578, 42 U.S.C. 7151).

(19) "Termination" means the end of employment with the licensee or, in the case of individuals not employed by the licensee, the end of a work assignment in the licensee's restricted areas in a given calendar quarter, without expectation or specific scheduling of reentry into the licensee's restricted areas during the remainder of that calendar quarter.

(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 § 20.203;

(2) "Radiation area" and "high radiation area" defined in § 20.202;

(3) "Personnel monitoring equipment" defined in § 20.202;

(4) "Survey" defined in § 20.201;

(5) Units of measurement of dose (rad, rem) defined in § 20.4;

(6) Units of measurment of radioactivity defined in § 20.5.

§ 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 in paragraphs (b) and (c) of this section.

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

(c) The rem, as used in this part, is a measure of the dose of any ionizing radiation to body tissues 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 paragraph (c)(3) of this section, one rem of neutron radiation may, for purposes of the regulations in this part, be assumed to be equivalent to 14 million neutrons per square centimeter incident upon the body; or, if there exists sufficient information to estimate with reasonable accuracy the approximate distribution in energy of the neutrons, the incident number of neutrons per square centimeter equivalent to one rem may be estimated from the following table:

NEUTRON FLUX DOSE EQUIVALENTS

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

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

§ 20.5 Units of radioactivity.

(a) Radioactivity is commonly, and for purposes of the regulations in this part shall be, measured in terms of disintegrations per unit time or in curies.

One curie = 3.7×10^{10} disintegrations per second (dps) = 2.2×10^{12} disintegrations per minute (dpm). Commonly used submultiples of the curie are the millicurie and the microcurie:

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

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

(b) [Deleted 40 FR 58704.]

(c) [Deleted 39 FR 23990.]

§ 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.

§ 20.7 Communications.

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

§ 20.8 Information collection requirements: OMB approval.

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). OMB has approved the information collection requirements contained in this part under control number 3150-0014.

(b) The approved information collection requirements contained in this part appear in §§ 20.105, 20.106, 20.201, 20.202, 20.203, 20.204, 20.205, 20.207, 20.301, 20.302, 20.303, 20.304, 20.305, 20.306, 20.307, 20.308, and 20.309.

(c) This part contains information collection requirements in addition to those approved under the control number specified in paragraph (a) of this section. These information collection requirements and the control numbers under which they are approved are as follows:

(1) In §§ 20.101 and 20.103, Form NRC-4 is approved under control number 3150-0078.

(2) In § 20.401, Form NRC-5 is approved under control number 3150-0004.

PERMISSIBLE DOSES, LEVELS, AND CONCENTRATIONS

§ 20.101 Radiation dose standards for individuals in restricted areas.

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

REMS PER CALENDAR QUARTER

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

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

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

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

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

§ 20.102 Determination of prior dose.

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

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

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

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

(c)(1) In the preparation of Form NRC-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 per quarter prior to Jan. 1, 1961	Column 2—Assumed exposure in rems per quarter beginning on or after Jan. 1, 1961
Whole body; head and trunk; active blood-forming organs; lens of eyes	3	1¼

(2) The licensee shall retain and preserve records used in preparing Form NRC-4 until the Commission authorizes their disposition.

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 § 20.101, the excess may be disregarded.

§ 20.103 Exposure of individuals to concentrations of radioactive materials in air in restricted areas.

(a)(1) No licensee shall possess, use, or transfer licensed material in such a manner as to permit any individual in a restricted area to inhale a quantity of radioactive material in any period of one calendar quarter greater than the quantity which would result from inhalation for 40 hours per week for 13 weeks at uniform concentrations of radioactive material in air specified in Appendix B, Table I, Column 1.[1][2] If the radioactive material is of such form that intake by absorption through the skin is likely, individual exposures to radioactive material shall be controlled so that the uptake of radioactive material by any organ from either inhalation or absorption or both routes of intake[3] in any calendar quarter does not exceed that which would result from inhaling such radioactive material for 40 hours per week for 13 weeks at uniform concentrations specified in Appendix B, Table I, Column 1.

(2) No licensee shall possess, use, or transfer mixtures of U-234, U-235, and U-238 in soluble form in such a manner as to permit any individual in a restricted area to inhale a quantity of such material in excess of the intake limits specified in Appendix B, Table I, Column 1 of this part. If such soluble uranium is of a form such that absorption through the skin is likely, individual exposures to such material shall be controlled so that the uptake of such material by any organ from either inhalation or absorption or both routes of intake[3] does not exceed that which would result from inhaling such material at the limits specified in Appendix B, Table I, Column 1 and footnote 4 thereto.

(3) For purposes of determining compliance with the requirements of this section the licensee shall use suitable measurements of concentrations of radioactive materials in air for detecting and evaluating airborne radioactivity in restricted areas and in addition, as appropriate, shall use measurements of radioactivity in the body, measurements of radioactivity excreted from the body, or any combination of such measurements as may be necessary for timely detection and assessment of individual intakes of radioactivity by exposed individuals. It is assumed that an individual inhales radioactive material at the airborne concentration in which he is present unless he uses respiratory protective equipment pursuant to paragraph (c) of this section. When assessment of a particular individual's intake of radioactive material is necessary, intakes less than those which would result from inhalation for 8 hours in any one day or for 10 hours in any one week at uniform concentrations specified in Appendix B, Table I, Column 1 need not be included in such assessment, provided that for any assessment in excess of these amounts the entire amount is included.

(b)(1) The licensee shall, as a precautionary procedure, use process or other engineering controls, to the extent practicable, to limit concentrations of radioactive materials in air to levels below those which delimit an airborne radioactivity area as defined in § 20.203(d)(1)(ii).

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

(c) When respiratory protective equipment is used to limit the inhalation of airborne radioactive material pursuant to paragraph (b)(2) of this section, the licensee shall use equipment that is certified or has certification extended by the National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA). The licensee may make allowance for the use of respiratory protective equipment in estimating exposures of individuals to this material provided that:

---

[1] Since the concentration specified for tritium oxide vapor assumes equal intakes by skin absorption and inhalation, the total intake permitted is twice that which would result from inhalation alone at the concentration specified for H-3 in Appendix B, Table I, Column 1 for 40 hours per week for 13 weeks.

[2] For radon-222, the limiting quantity is that inhaled in a period of one calendar year. For radioactive materials designated "Sub" in the "Isotope" column of the table, the concentration value specified is based upon exposure to the material as an external radiation source. Individual exposures to these materials may be accounted for as part of the limitation on individual dose in § 20.101. These nuclides shall be subject to the precautionary procedures required by § 20.103(b)(1).

[3] Multiply the concentration value specified in Appendix B, Table I, Column 1, by 6.9×10^{4} ml to obtain the quarterly quantity limit. Multiply the concentration value specified in Appendix B, Table I, Column 1, by 3.5×10^{5} ml to obtain the annual quantity limit for Rn-222.

[4] Significant intake by ingestion or injection is presumed to occur only as a result of circumstances such as accident, inadvertence, poor procedure, or similar special conditions. Such intakes must be evaluated and accounted for by techniques and procedures as may be appropriate to the circumstances of the occurrence. Exposures so evaluated shall be included in determining whether the limitation on individual exposures in § 20.103(a)(1) has been exceeded.

[5] Regulatory guidance on assessment of individual intakes of radioactive material is given in Regulatory Guide 8.9, "Acceptable Concepts, Models, Equations and Assumptions for a Bioassay Program," single copies of which are available from the Office of Standards Development, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, upon written request.

(1) The licensee selects respiratory protective equipment that provides a protection factor greater than the multiple by which peak concentrations of airborne radioactive materials in the working area are expected to exceed the values specified in Appendix B, Table I, Column 1 of this part. The equipment so selected shall be used so that the average concentration of radioactive material in the air that is inhaled during any period of uninterrupted use in an airborne radioactivity area, on any day, by any individual using the equipment, does not exceed the values specified in Appendix B, Table I, Column 1 of this part. For the purpose of this paragraph, the concentration of radioactive material in the air that is inhaled when respirators are worn may be estimated by dividing the ambient concentration in air by the protection factor specified in Appendix A of this part. If the exposure is later found to be greater than estimated, the corrected value shall be used; if the exposure is later found to be less than estimated, the corrected value may be used.

(2) The licensee maintains and implements a respiratory protection program that includes, as a minimum: air sampling sufficient to identify the hazard, permit proper equipment selection and estimate exposures; surveys and bioassays as appropriate to evaluate actual exposures; written procedures regarding selection, fitting, and maintenance of respirators, and testing of respirators for operability immediately prior to each use; written procedures regarding supervision and training of personnel and issuance records; and determination by a physician prior to initial use of respirators, and at least every 12 months thereafter, that the individual user is physically able to use the respiratory protective equipment.

(3) A written policy statement on respirator usage shall be issued covering such things as: use of practicable engineering controls instead of respirators; routine, nonroutine, and emergency use of respirators; and periods of respirator use and relief from respirator use. The licensee shall advise each respirator user that the user may leave the area at any time for relief from respirator use in the event of equipment malfunction, physical or psychological distress, procedural or communication failure, significant deterioration of operating conditions, or any other condition that might require such relief.

(4) The licensee uses equipment within limitations for type and mode of use and provides proper visual, communication, and other special capabilities (such as adequate skin protection) when needed.

(d) Unless otherwise authorized by the Commission, the licensee shall not assign protection factors in excess of those specified in Appendix A of this part in selecting and using respiratory protective equipment. The Commission may authorize a licensee to use higher protection factors on receipt of an application (1) describing the situation for which a need exists for higher protection factors, and (2) demonstrating that the respiratory protective equipment will provide these higher protection factors under the proposed conditions of use.

(e) Where equipment of a particular type has not been tested and certified, or test certification extended, by NIOSH/MSHA, or where there is no existing schedule for test and certification of certain equipment, the licensee shall not make allowances for this equipment without specific authorization by the Commission. An application for this authorization must include a demonstration by testing, or on the basis of reliable test information, that the material and performance characteristics of the equipment are capable of providing the proposed degree of protection under anticipated conditions of use.

(f) Only equipment that has been specifically certified or had certification extended for emergency use by NIOSH/MSHA shall be used as emergency devices.

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

§ 20.104 Exposure of minors.

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

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

§ 20.105 Permissible levels of radiation in unrestricted areas.

(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.

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

§ 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.

[29 FR 19328]

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

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

[29 FR 19328]

§ 20.107 Medical diagnosis and therapy.

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.

§ 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

§ 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.

[29 FR 19328]

(b) Each licensee shall make or cause to be made such surveys as (1) may be necessary for the licensee to comply with the regulations in this part, and (2) are reasonable under the circumstances to evaluate the extent of radiation hazards that may be present.

§ 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 § 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 § 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 millirems;

(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.

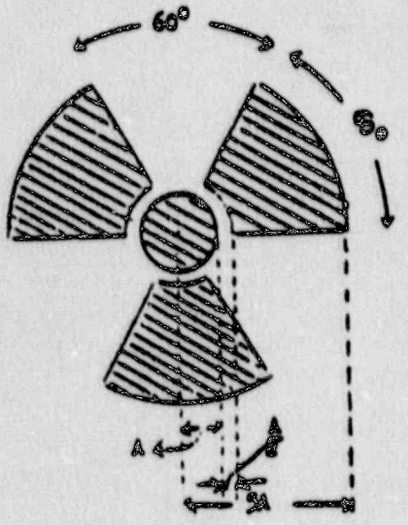
PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

§ 20.203 Caution signs, labels, signals and controls.

(a) *General.* (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 [1]

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 [1]

HIGH RADIATION AREA

[1] Or "Danger".

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

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

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

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

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

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

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

(6) Each area in which there may exist radiation levels in excess of 5 rems in one hour at one meter from a sealed radio-active source [1] that is used to irradiate materials shall: [2]

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

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

(iii) Be equipped with control devices such that upon failure or removal of physical radiation barriers other than the source's shielded storage container the radiation level from the source shall be reduced below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour; and visible and audible alarm signals shall be generated to make potentially affected individuals aware of the hazard and the licensee or at least one other individual, who is familiar with the activity and prepared to render or summon assistance, aware of the failure or removal of the physical barrier. When the shield for the stored source is a liquid, means shall be provided to monitor the integrity of the shield and to signal, automatically, loss of adequate shielding. Physical radiation barriers that com-

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

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

prise permanent structural components, such as walls, that have no credible probability of failure or removal in ordinary circumstances need not meet the requirements of this paragraph (c)(6)(iii).

(iv) Be equipped with devices that will automatically generate visible and audible alarm signals to alert personnel in the area before the source can be put into operation and in sufficient time for any individual in the area to operate a clearly identified control device which shall be installed in the area and which can prevent the source from being put into operation.

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

(vi) Be checked by a physical radiation measurement to assure that prior to the first individual's entry into the area after any use of the source, the radiation level from the source in the area is below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour.

(vii) Have entry control devices required in paragraph (c)(6)(i) of this section which have been tested for proper functioning prior to initial operation with such source of radiation on any day that operations are not uninterruptedly continued from the previous day or before resuming operations after any unintended interruption, and for which records are kept of the dates, times, and results of such tests of function. No operations other than those necessary to place the source in safe condition or to effect repairs on controls shall be conducted with such source unless control devices are functioning properly. The licensee shall submit an acceptable schedule for more complete periodic tests of the entry control and warning systems to be established and adhered to as a condition of the license.

(viii) Have those entry and exit portals that are used in transporting materials to and from the irradiation area, and that are not intended for use by individuals, controlled by such devices and administrative procedures as are necessary to physically protect and warn against inadvertent entry by any individual through such portals. Exit portals for processed materials shall be equipped to detect and signal the presence of loose radiation sources that are carried toward such an exit and to automatically prevent such loose sources from being carried out of the area.

(7) Licensees with, or applicants for, licenses for radiation sources that are within the purview of paragraph (c)(6) of this section, and that must be used in a variety of positions or in peculiar locations, such as open fields or forests, that make it impracticable to comply with certain requirements of paragraph (c)(6) of this section, such as those for the automatic control of radiation levels, may apply to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, for approval, prior to use of safety measures that are alternative to those specified in paragraph (c)(6) of this section, and that will provide at least an equivalent degree of personnel protection in the use of such sources. At least one of the alternative measures must include an entry-preventing interlock control based on a physical measurement of radiation that assures the absence of high radiation levels before an individual can gain access to an area where such sources are used.

(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 material composed wholly or partly of licensed material, exist in concentrations in excess of the amounts specified in Appendix B, Table I, Column 1 of this part; 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 percent of the amounts specified in Appendix B Table I, Column 1 of this part.

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

CAUTION [1]

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 amount exceeding 10 times the quantity of such material specified in Appendix C of this part shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION [1]

RADIOACTIVE MATERIAL(S)

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

CAUTION [1]

RADIOACTIVE MATERIAL(S)

(f) *Containers.* (1) Except as provided in paragraph (f)(3) of this section, each container of licensed material shall bear a durable, clearly visible label identifying the radioactive contents.

(2) A label required pursuant to paragraph (f)(1) of this section shall bear the radiation caution symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL". It shall also provide sufficient information [2] to permit individuals handling or using the containers, or working in the vicinity thereof, to take precautions to avoid or minimize exposure.

(3) Notwithstanding the provisions of paragraph (f)(1) of this section labeling is not required:

(i) For containers that do not contain licensed materials in quantities greater than the applicable quantities listed in Appendix C of this part.

(ii) For containers containing only natural uranium or thorium in quantities no greater than 10 times the applicable quantities listed in Appendix C of this part.

(iii) For containers that do not contain licensed materials in concentrations greater than the applicable concentrations listed in Appendix B, Table I, Column 2, of this part.

(iv) For containers when they are attended by an individual who takes the precautions necessary to prevent the exposure of any individual to radiation or radioactive materials in excess of the limits established by the regulations in this part.

(v) For containers when they are in transport and packaged and labeled in accordance with regulations of the Department of Transportation.

(vi) For containers which are accessible [2] only to individuals authorized to handle or use them, or to work in the vicinity thereof, provided that the contents are identified to such individuals by a readily available written record.

(vii) For manufacturing or process equipment, such as nuclear reactors, reactor components, piping, and tanks.

[1] Or "Danger".

[2] As appropriate, the information will include radiation levels, kinds of material, estimate of activity, date for which activity is estimated, mass enrichment, etc.

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

§ 20.204 Signs; exceptions.

Notwithstanding the provisions of § 20.203,

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

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

(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.

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

[1] For example, containers in locations such as water-filled canals, storage vaults, or hot cells.

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

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

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

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

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

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

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

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

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

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

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

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

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

TABLE OF EXEMPT AND TYPE A QUANTITIES

Transport group[1]	Exempt quantity limit (in millicuries)	Type A quantity limit (in curies)
I	0.1	0.001
II	0.1	0.05
III	1	3
IV	1	20
V	1	20
VI	1	1000
VII	10,000	1000
Uranium, Plutonium	1	20

[1] The definitions of "transport group" and uranium and plutonium are contained in § 71.4 of this chapter.

[Footnote 1 removed 49 FR 19623]

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

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

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

(d) Each licensee shall establish and maintain procedures for safely opening packages in which licensed material is received, and shall assure that such procedures are followed and that due consideration is given to special instructions for the type of package being opened.

§ 20.206 Instruction of personnel.

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

§ 20.207 Storage and control of licensed materials in unrestricted areas.

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

(b) Licensed materials in an unrestricted area and not in storage shall be

tended under the constant surveillance and immediate control of the licensee.

Waste Disposal

§ 20.301 General requirement.

No licensee shall dispose of licensed material except:

(a) By transfer to an authorized recipient as provided in the regulations in Parts 30, 40, 60, 61, 70 or 72 of this chapter, whichever may be applicable; or

(b) As authorized under § 20.302 or Part 61 of this chapter; or

(c) As provided in § 20.303, applicable to the disposal of licensed material by release into sanitary sewerage systems, or in § 20.306 for disposal of specific wastes, or in § 20.106 (Radioactivity in effluents to unrestricted areas).

§ 20.302 Method for obtaining approval of proposed disposal procedures.

(a) 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 and any other radioactive material involved, including the quantities and kinds of such material and the 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.

(b) The Commission will not approve any application for a license for disposal of licensed material at sea unless the applicant shows that sea disposal offers less harm to man or the environment than other practical alternative methods of disposal.

§ 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 paragraphs (b)(1) or (2) of this section.

(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 3 of this part; or

(2) Ten times the quantity of such material specified in Appendix C of this part; 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 3 of this part; and

(d) The gross quantity of licensed and other radioactive material, excluding hydrogen-3 and carbon-14, released into the sewerage system by the licensee does not exceed one curie per year.

The quantities of hydrogen-3 and carbon-14 released into the sanitary sewerage system may not exceed 5 curies per year for hydrogen-3 and 1 curie per year for carbon-14. Excreta from individuals undergoing medical diagnosis or therapy with radioactive material shall be exempt from any limitations contained in this section.

§ 20.306 Treatment or disposal by incineration.

No licensee shall treat or dispose of licensed material by incineration, except for materials listed under § 20.306 or as specifically approved by the Commission pursuant to §§ 20.106(b) and 20.302.

§ 20.306 Disposal of specific wastes.

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

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

(b) 0.05 microcuries or less of hydrogen-3 or carbon-14, per gram of animal tissue averaged over the weight of the entire animal; provided however, tissue may not be disposed of under this section in a manner that would permit its use either as food for humans or as animal feed.

(c) Nothing in this section, however, relieves the licensee of maintaining records showing the receipt, transfer and disposal of such byproduct material as specified in § 30.51 of this chapter; and

(d) Nothing in this section relieves the licensee from complying with other applicable Federal, State or local regulations governing any other toxic or hazardous property of the materials.

§ 20.311 Transfer for disposal and manifests.

(a) Purpose. The requirements of this section are designed to control transfers of radioactive waste intended for disposal at a land disposal facility and establish a manifest tracking system and supplement existing requirements concerning transfers and recordkeeping for such wastes. The reporting and recordkeeping requirements contained in this section have been approved by the Office of Management and Budget OMB approval No. 3150-0014.

(b) Each shipment of radioactive waste to a licensed land disposal facility must be accompanied by a shipment manifest that contains the name, address, and telephone number of the person generating the waste. The manifest shall also include the name, address, and telephone number or the name and EPA hazardous waste identification number of the person transporting the waste to the land disposal facility. The manifest must also indicate as completely as practicable: a physical description of the waste; the volume; radionuclide identity and quantity; the total radioactivity; and the principal chemical form. The solidification agent must be specified. Waste containing more than 0.1% chelating agents by weight must be identified and the weight percentage of the chelating agent estimated. Wastes classified as Class A, Class B, or Class C in § 61.55 of this chapter must be clearly identified as such in the manifest. The total quantity of the radionuclides H-3, C-14, Tc-99 and I-129 must be shown. The manifest required by this paragraph may be shipping papers used to meet Department of Transportation or

Environmental Protection Agency regulations or requirements of the receiver, provided all the required information is included. Copies of manifests required by this section may be legible carbon copies or legible photocopies.

(c) Each manifest must include a certification by the waste generator that the transported materials are properly classified, described, packaged, marked, and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation and the Commission. An authorized representative of the waste generator shall sign and date the manifest.

(d) Any generating licensee who transfers radioactive waste to a land disposal facility or a licensed waste collector shall comply with the requirements in paragraphs (d)(1) through (8) of this section. Any generating licensee who transfers waste to a licensed waste processor who treats or repackages waste shall comply with the requirements of paragraphs (d)(4) through (8) of this section. A licensee shall:

(1) Prepare all wastes so that the waste is classified according to § 61.55 and meets the waste characteristics requirements in § 61.56 of this chapter;

(2) Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with § 61.55 of this chapter;

(3) Conduct a quality control program to assure compliance with §§ 61.55 and 61.56 of this chapter; the program must include management evaluation of audits;

(4) Prepare shipping manifests to meet the requirements of §§ 20.311 (b) and (c) of this part;

(5) Forward a copy of the manifest to the intended recipient, at the time of shipment; or, deliver to a collector at the time the waste is collected, obtaining acknowledgement of receipt in the form of a signed copy of the manifest or equivalent documentation from the collector;

(6) Include one copy of the manifest with the shipment;

(7) Retain a copy of the manifest and documentation of acknowledgement of receipt as the record of transfer of licensed material as required by Parts 20, 40, and 70 of this chapter; and,

(8) For any shipments or any part of a shipment for which acknowledgement of receipt has not been received within the times set forth in this section, conduct an investigation in accordance with paragraph (h) of this section.

(e) Any waste collector licensee who handles only prepackaged waste shall:

(1) Acknowledge receipt of the waste from the generator within one week of receipt by returning a signed copy of the manifest or equivalent documentation;

(2) Prepare a new manifest to reflect consolidated shipments; the new manifest shall serve as a listing or index for the detailed generator manifests. Copies of the generator manifests shall be a part of the new manifest. The waste collector may prepare a new manifest without attaching the generator manifests, provided the new manifest contains for each package the information specified in paragraph (b) of this section. The collector licensee shall certify that nothing has been done to the waste which would invalidate the generator's certification;

(3) Forward a copy of the new manifest to the land disposal facility operator at the time of shipment;

(4) Include the new manifest with the shipment to the disposal site;

(5) Retain a copy of the manifest and documentation of acknowledgement of receipt as the record of transfer of licensed material as required by Parts 20, 40, and 70 of this chapter, and retain information from generator manifests until disposition is authorized by the Commission; and,

(6) For any shipments or any part of a shipment for which acknowledgement of receipt is not received within the times set forth in this section, conduct an investigation in accordance with paragraph (h) of this section.

(f) Any licensed waste processor who treats or repackages wastes shall:

(1) Acknowledge receipt of the waste from the generator within one week of receipt by returning a signed copy of the manifest or equivalent documentation;

(2) Prepare a new manifest that meets the requirements of paragraphs (b) and (c) of this section. Preparation of the new manifest reflects that the processor is responsible for the waste;

(3) Prepare all wastes so that the waste is classified according to § 61.55 and meets the waste characteristics requirements in § 61.56 of this chapter;

(4) Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with §§ 61.55 and 61.57 of this chapter;

(5) Conduct a quality control program to assure compliance with §§ 61.55 and 61.56 of this chapter. The program shall include management evaluation of audits;

(6) Forward a copy of the new manifest to the disposal site operator or waste collector at the time of shipment, or deliver to a collector at the time the waste is collected, obtaining acknowledgement of receipt in the form of a signed copy of the manifest or equivalent documentation by the collector;

(7) Include the new manifest with the shipment;

(8) Retain copies of original manifests and new manifests and documentation of acknowledgement of receipt as the record of transfer of licensed material required by Parts 20, 40, and 70 of this chapter; and

(9) For any shipment or part of a shipment for which acknowledgement is not received within the times set forth in this section, conduct an investigation in accordance with paragraph (h) of this section.

(g) The land disposal facility operator shall:

(1) Acknowledge receipt of the waste within one week of receipt by returning a signed copy of the manifest or equivalent documentation to the shipper. The shipper to be notified is the licensee who last possessed the waste and transferred the waste to the operator. The returned copy of the manifest or equivalent documentation shall indicate any discrepancies between materials listed on the manifest and materials received;

(2) Maintain copies of all completed manifests or equivalent documentation until the Commission authorizes their disposition; and

(3) Notify the shipper (i.e., the generator, the collector, or processor) and the Director of the nearest Commission Regional Office listed in Appendix D of this part when any shipment or part of a shipment has not arrived within 60 days after the advance manifest was received.

(h) Any shipment or part of a shipment for which acknowledgement is not received within the times set forth in this section, must:

(1) Be investigated by the shipper if the shipper has not received notification of receipt within 20 days after transfer; and

(2) Be traced and reported. The investigation shall include tracing the shipment and filing a report with the nearest Commission Regional Office listed in Appendix D of this part. Each licensee who conducts a trace investigation shall file a written report with the nearest Commission's Regional office within 2 weeks of completion of the investigation.

§ 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 § 20.202 of the regulations in this part. Such records shall be kept on Form NRC-5, in accordance with the instructions contained in that form or on clear and legible records containing all the information required by Form NRC-5. The doses entered on the forms or records shall be for periods of time not exceeding one calendar quarter.

(b) Each licensee shall maintain records in the same units used in this part, showing the results of surveys required by [illegible], monitoring required by [illegible], and disposals made under §§ 20.302, 20.303, removed § 20.304,' and Part 61 of this chapter.

(c)(1) Records of individual exposure to radiation and to radioactive material which must be maintained pursuant to the provisions of paragraph (a) of this section and records of bioassays, including results of whole body counting examinations, made pursuant to § 20.103, shall be preserved until the Commission authorizes disposition.

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

(3) Records of disposal of licensed materials made pursuant to §§ 20.304, 20.305, removed § 20.304,[1] and Part 61 of this chapter are to be maintained until the Commission authorizes their disposition.

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

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

[47 FR 57446] [47 FR 57446]

[49 FR 19626]

§ 20.402 Reports of theft or loss of licensed material.

(a)(1) Each licensee shall report to the Commission, by telephone, immediately after it determines that a loss or theft of licensed material has occurred in such quantities and under such circumstances that it appears to the licensee that a substantial hazard may result to persons in unrestricted areas.

(2) Reports must be made as follows:

(i) Licensees having an installed Emergency Notification System shall make the reports to the NRC Operations Center in accordance with § 50.72 of this chapter.

(ii) All other licensees shall make reports to the Administrator of the appropriate NRC Regional Office listed in Appendix D of this part.

(b) Each licensee who makes a report under paragraph (a) of this section shall, within 30 days after learning of the loss or theft, make a report in writing to the U.S. Nuclear Regulatory Commission, Document Control Desk, Washington, D.C. 20555, with a copy to the appropriate NRC Regional Office listed in Appendix D of this part. The report shall include the following information:

[49 FR 19626]

[49 FR 19626]

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

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

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

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

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

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

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

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

[49 FR 19626]

(e) For holders of an operating license for a nuclear power plant, the events included in paragraph (b) of this section must be reported in accordance with the procedures described in § 50.73 (b), (c), (d), (e), and (g) of this chapter and must include the information required in paragraph (b) of this section. Events reported in accordance with § 50.73 of this chapter need not be reported by a duplicate report under paragraph (b) of this section.

[49 FR 19626] [49 FR 19626]

[49 FR 19626]

§ 20.403 Notifications of incidents.

(a) *Immediate notification.* Each licensee shall immediately report any events involving byproduct, source, or special nuclear material possessed by the licensee that may have caused or threatens to cause:

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

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

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

[49 FR 19626]

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

[49 FR 19626]

(b) *Twenty-four hour notification.* Each licensee shall within 24 hours of discovery of the event, report any event involving licensed material possessed by the licensee that 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 of this part; or

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

[49 FR 19626]

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

[49 FR 19626]

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

[49 FR 19626]

(d) Reports made by licensees in response to the requirements of this section must be made as follows:

(1) Licensees that have an installed Emergency Notification System shall make the reports required by paragraphs (a) and (b) of this section to the NRC Operations Center in accordance with § 50.72 of this chapter.

(2) All other licensees shall make the reports required by paragraphs (a) and (b) of this section by telephone and by telegram, mailgram, or facsimile to the Administrator of the appropriate NRC Regional Office listed in Appendix D of this part.

§ 20.404 [Reserved]

[49 FR 19626]

§ 20.405 Reports of overexposures and excessive levels and concentrations.

(a)(1) In addition to any notification required by § 20.403 of this part, each licensee shall make a report in writing concerning any one of the following types of incidents within 30 days of its occurrence:

(i) Each exposure of an individual to radiation in excess of the applicable limits in §§ 20.101 or 20.104(a) of this part, or the license;

(ii) Each exposure of an individual to radioactive material in excess of the applicable limits in §§ 20.103(a)(1), 20.103(a)(2), or 20.104(b) of this part, or in the license;

[49 FR 19626]

(iii) Levels of radiation or concentrations of radioactive material in a restricted area in excess of any other applicable limit in the license;

(iv) Any incident for which notification is required by § 20.402 of this part; or

(v) Levels of radiation or concentrations of radioactive material (whether or 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 license.

(2) Each report required under paragraph (a)(1) of this section must describe the extent of exposure of individuals to radiation or to radioactive material, including:

(i) Estimates of each individual's exposure as required by paragraph (b) of this section;

(ii) Levels of radiation and concentrations of radioactive material involved;

(iii) The cause of the exposure, levels or concentrations; and

(iv) Corrective steps taken or planned to prevent a recurrence.

(b) Any report filed with the Commission pursuant to paragraph (a) of this section shall include for each individual exposed the name, social security number, and date of birth, and an estimate of the individual's exposure. The report shall be prepared so that this information is stated in a separate part of the report.

(c)(1) In addition to any notification required by § 20.402 of this part, each licensee shall make a report in writing of levels of radiation or release of radioactive material in excess of limits specified by 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," or in excess of license conditions related to compliance with 40 CFR Part 190.

(2) Each report submitted under paragraph (c)(1) of this section must describe:

(i) The extent of exposure of individuals to radiation or to radioactive material;

(ii) Levels of radiation and concentrations of radioactive material involved;

(iii) The cause of the exposure, levels, or concentrations; and

(iv) Corrective steps taken or planned to assure against a recurrence, including the schedule for achieving conformance with 40 CFR Part 190 and with associated license conditions.

(d) For holders of an operating license for a nuclear power plant, the incidents included in paragraphs (a) or (c) of this section must be reported in accordance with the procedures described in paragraphs 50.73 (b), ... (d), (e), and (g) of this chapter and must also include the information required by paragraphs (a) and (c) of this section. Incidents reported in accordance with § 50.73 of this chapter need not be reported by a duplicate report under paragraphs (a) or (c) of this section.

(e) All other licensees who make reports under paragraphs (a) or (c) of this section shall, within 30 days after learning of the overexposure or excessive level or concentration, make a report in writing to the U.S. Nuclear Regulatory Commission, Document Control Desk, Washington, D.C. 20555, with a copy to the appropriate NRC Regional Office listed in Appendix D of this part.

§ 20.406 [Reserved]

§ 20.407 Personnel monitoring reports.

Each person described in § 20.408 of this part shall, within the first quarter of each calendar year, submit to the Director, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC 20555, the reports specified in paragraphs (a) and (b) of this section, covering the preceding calendar year.[1]

(a) A report of either (1) the total number of individuals for whom personnel monitoring was required under § 20.202(a) or § 34.33(a) of this chapter during the calendar year; or (2) the total number of individuals for whom personnel monitoring was provided during the calendar year: *Provided, however,* That such total includes at least the number of individuals required to be reported under paragraph (a)(1) of this section. The report shall indicate whether it is submitted in accordance with paragraph (a)(1) or (a)(2) of this section. If personnel monitoring was not required to be provided to any individual by the licensee under §§ 20.202(a) or 34.33(a) of this chapter during the calendar year, the licensee shall submit a negative report indicating that such personnel monitoring was not required.

(b) A statistical summary report of the personnel monitoring information recorded by the licensee for individuals for whom personnel monitoring was either required or provided, as described in paragraph (a) of this section, indicating the number of individuals whose total whole body exposure recorded during the previous calendar year was in each of the following estimated exposure ranges:

Exposure range (rem)	Number of individuals in each range
No measurable exposure	
Measurable exposure less than 0.1	
0.1 to 0.25	
0.25 to 0.5	
0.5 to 0.75	
0.75 to 1	
1 to 2	
2 to 3	
3 to 4	
4 to 5	
5 to 6	
6 to 7	
7 to 8	
8 to 9	
9 to 10	
10 to 11	
11 to 12	
12+	

Radiation values exactly equal to the values separating exposure ranges shall be reported in the higher range.

The low exposure range data are required in order to obtain better information about the exposures actually received. This section does not require improved measurements.

§ 20.408 Reports of personnel monitoring on termination of employment or work.

(a) This section applies to each person licensed by the Commission to:

(1) Operate a nuclear reactor designed to produce electrical or heat energy pursuant to § 50.21(b) or § 50.22 of this chapter or a testing facility as defined in § 50.2(r) of this chapter;

(2) Possess or use byproduct material for purposes of radiography pursuant to Parts 30 and 34 of this chapter;

(3) Possess or use at any one time, for purposes of fuel processing, fabricating, or reprocessing, special nuclear material in a quantity exceeding 9,000 grams of contained uranium-235, uranium-233, or plutonium or any combination thereof pursuant to Part 70 of this chapter;

(4) Possess high-level radioactive waste at a geologic repository operations area pursuant to Part 60 of this chapter; or

(5) Possess spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to Part 72 of this chapter; or

(6) Possess or use at any one time, for processing or manufacturing for distribution pursuant to Parts 30, 32, or 33 of this Chapter, byproduct material in quantities exceeding any one of the following quantities:

[1] A licensee whose license expires or terminates prior to, or on the last day of the calendar year, shall submit reports at the expiration or termination of the license, covering that part of the year during which the license was in effect.

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

[49 FR 44927]

[1] The Commission may require as a license condition, or by rule, regulation or order pursuant to § 20.501, reports from licensees who are licensed to use radionuclides not on this list, in quantities sufficient to cause comparable radiation doses.

[47 FR 57446]

(7) Receive radioactive waste from other persons for disposal under Part 61 of this chapter.

[56 FR 23391]

(b) When an individual terminates employment with a licensee described in paragraph (a) of this section, or an individual assigned to work in such a licensee's facility, but not employed by the licensee, completes the work assignment in the licensee's facility, the licensee shall furnish to the Director, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC 20555, a report of the individual's exposures to radiation and radioactive material, measured during the period of employment or work assignment in the licensee's facility, containing information recorded by the licensee pursuant to §§ 20.401(a) and 20.103. Such report shall be furnished within 30 days after the exposure of the individual has been determined by the licensee or 30 days after the date of termination of employment or work assignment, whichever is earlier.

[56 FR 23391]

§ 20.409 Notifications and reports to individuals.

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

(b) When a licensee is required pursuant to §§ 20.405 or 20.406 to report to the Commission any exposure of an individual to radiation or radioactive material, the licensee shall also notify the individual. Such notice shall be transmitted at a time not later than the transmittal to the Commission, and shall comply with the provisions of § 19.13(a) of this chapter.

Exceptions and Additional Requirements

§ 20.501 Applications for exemptions.

The Commission may, upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

§ 20.502 Additional requirements.

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

Enforcement

§ 20.601 Violations.

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

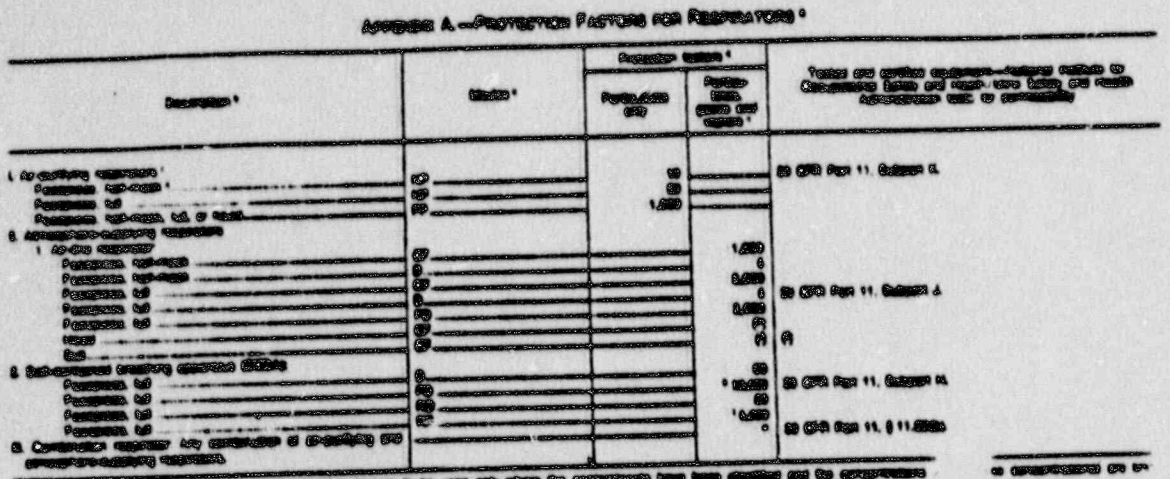
[56 FR 23391]

[Note removed 49 FR 19623]

App. A

PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

APPENDIX A.—PROTECTION FACTORS FOR RESPIRATORS[1]



[1] FR 19511

Note 1.—Protection factors for respirators as may be approved by the U.S. Bureau of Mines/National Institute for Occupational Safety and Health (MSHA) according to applicable approvals for respirators for type and mode of use to protect against airborne radionuclides, may be used in this context that they do not exceed the protection factors listed in this table. The protection factors listed in this table may not be appropriate in circumstances where chemical or other nonrespiratory hazards exist in addition to radiological hazards. The selection and use of respirators for these circumstances should take into account applicable approvals of the U.S. Bureau of Mines/NIOSH.

Note 2.—Radioactive contaminants for which the concentration values in Table I, column 1, Appendix B of this part are based on internal dose due to inhalation may, in addition, present external exposure hazards at higher concentrations. Under these circumstances, limitations on occupancy may have to be governed by external dose limits.

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	Column 2	Column 1	Column 2
			Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Actinium (89)	Ac 227	S	2×10^{-12}	6×10^{-8}	8×10^{-14}	2×10^{-9}
		I	2×10^{-11}	9×10^{-8}	9×10^{-13}	3×10^{-9}
	Ac 228	S	8×10^{-9}	2×10^{-5}	3×10^{-10}	9×10^{-7}
		I	2×10^{-8}	3×10^{-5}	6×10^{-10}	9×10^{-7}
Americium (95)	Am 241	S	6×10^{-12}	1×10^{-8}	2×10^{-13}	4×10^{-9}
		I	1×10^{-10}	6×10^{-8}	4×10^{-12}	2×10^{-8}
	Am 242m	S	6×10^{-12}	1×10^{-8}	2×10^{-13}	4×10^{-9}
		I	2×10^{-10}	2×10^{-8}	9×10^{-13}	9×10^{-9}
	Am 243	S	4×10^{-12}	4×10^{-9}	1×10^{-13}	1×10^{-9}
		I	2×10^{-10}	4×10^{-8}	2×10^{-12}	1×10^{-8}
	Am 245	S	6×10^{-10}	1×10^{-7}	2×10^{-11}	4×10^{-8}
		I	1×10^{-10}	8×10^{-8}	4×10^{-12}	2×10^{-8}
	Am 246	S	4×10^{-9}	1×10^{-6}	1×10^{-11}	3×10^{-7}
		I	2×10^{-9}	1×10^{-6}	6×10^{-11}	3×10^{-7}
Antimony (51)	Sb 122	S	2×10^{-7}	3×10^{-4}	6×10^{-9}	5×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
	Sb 124	S	3×10^{-7}	7×10^{-4}	3×10^{-9}	2×10^{-5}
		I	3×10^{-9}	7×10^{-4}	7×10^{-10}	2×10^{-5}
	Sb 125	S	9×10^{-7}	3×10^{-3}	3×10^{-8}	1×10^{-4}
		I	3×10^{-9}	3×10^{-3}	9×10^{-10}	1×10^{-4}
Argon (18)	A 37	Sub[2]	6×10^{-3}	.....	1×10^{-4}	
	A 41	Sub	2×10^{-8}	.....	4×10^{-9}	
Arsenic (33)	As 73	S	2×10^{-6}	1×10^{-3}	7×10^{-8}	5×10^{-4}
		I	4×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-4}
	As 74	S	5×10^{-7}	2×10^{-4}	1×10^{-8}	8×10^{-5}
		I	1×10^{-7}	2×10^{-4}	4×10^{-9}	8×10^{-5}
	As 76	S	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-4}
		I	1×10^{-7}	6×10^{-4}	3×10^{-9}	2×10^{-4}
	As 77	S	8×10^{-7}	4×10^{-4}	3×10^{-8}	6×10^{-4}
		I	4×10^{-7}	3×10^{-4}	1×10^{-8}	6×10^{-4}
Astatine (85)	At 211	S	7×10^{-10}	3×10^{-7}	2×10^{-11}	1×10^{-7}
		I	9×10^{-9}	2×10^{-7}	1×10^{-10}	7×10^{-7}
Barium (56)	Ba 131	S	1×10^{-6}	5×10^{-4}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-4}	1×10^{-8}	2×10^{-4}
	Ba 140	S	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-4}
		I	4×10^{-8}	7×10^{-4}	1×10^{-9}	2×10^{-4}
Berkelium (97)	Bk 249	S	9×10^{-10}	2×10^{-7}	3×10^{-11}	6×10^{-8}
		I	1×10^{-7}	2×10^{-7}	4×10^{-9}	6×10^{-8}
	Bk 250	S	1×10^{-7}	6×10^{-4}	3×10^{-9}	2×10^{-4}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-4}
Beryllium (4)	Be 7	S	6×10^{-7}	3×10^{-3}	2×10^{-7}	2×10^{-3}
		I	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-3}
Bismuth (83)	Bi 206	S	2×10^{-7}	1×10^{-4}	6×10^{-9}	4×10^{-5}
		I	1×10^{-7}	1×10^{-4}	3×10^{-9}	4×10^{-5}
	Bi 207	S	2×10^{-7}	3×10^{-4}	6×10^{-9}	6×10^{-5}
		I	1×10^{-7}	3×10^{-4}	3×10^{-9}	6×10^{-5}
	Bi 210	S	6×10^{-9}	1×10^{-5}	2×10^{-10}	4×10^{-6}
		I	6×10^{-9}	1×10^{-5}	2×10^{-10}	4×10^{-6}
	Bi 212	S	1×10^{-7}	1×10^{-4}	3×10^{-9}	4×10^{-5}
		I	3×10^{-9}	1×10^{-4}	7×10^{-10}	4×10^{-5}

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	Column 2	Column 1	Column 2
			Air	Water	Air	Water
		†	(μCi/ml)	(μCi/ml)	(μCi/ml)	(μCi/ml)
Bromine (35)	Br 82	S	1 x 10⁻⁶	3 x 10⁻³	6 x 10⁻⁸	3 x 10⁻⁴
Cadmium (48)	Cd 109	S	3 x 10⁻⁸	1 x 10⁻⁴	3 x 10⁻⁹	4 x 10⁻⁶
			3 x 10⁻⁷	8 x 10⁻³	9 x 10⁻⁹	3 x 10⁻⁴
	Cd 115m	S	7 x 10⁻⁸	2 x 10⁻⁴	2 x 10⁻⁹	8 x 10⁻⁶
			4 x 10⁻⁷	9 x 10⁻³	1 x 10⁻⁸	3 x 10⁻⁴
	Cd 115	S	4 x 10⁻⁸	2 x 10⁻⁴	1 x 10⁻⁹	7 x 10⁻⁶
			2 x 10⁻⁷	7 x 10⁻³	6 x 10⁻⁹	2 x 10⁻⁴
Calcium (20)	Ca 45	S	2 x 10⁻⁷	1 x 10⁻⁴	6 x 10⁻⁹	4 x 10⁻⁶
			3 x 10⁻⁶	8 x 10⁻²	1 x 10⁻⁷	3 x 10⁻³
	Ca 47	S	1 x 10⁻⁷	5 x 10⁻⁶	4 x 10⁻⁹	2 x 10⁻⁴
			9 x 10⁻⁸	1 x 10⁻⁴	6 x 10⁻⁹	3 x 10⁻⁶
			3 x 10⁻⁷	1 x 10⁻²	6 x 10⁻⁸	3 x 10⁻³
Californium (98)	Cf 249	S	3 x 10⁻¹⁰	1 x 10⁻⁷	8 x 10⁻¹²	4 x 10⁻⁹
			1 x 10⁻⁹	7 x 10⁻⁷	3 x 10⁻¹¹	2 x 10⁻⁸
	Cf 250	S	3 x 10⁻¹⁰	4 x 10⁻⁷	9 x 10⁻¹²	1 x 10⁻⁸
			1 x 10⁻⁹	7 x 10⁻⁷	3 x 10⁻¹¹	3 x 10⁻⁸
	Cf 251	S	2 x 10⁻¹⁰	1 x 10⁻⁷	6 x 10⁻¹²	4 x 10⁻⁹
			1 x 10⁻⁹	8 x 10⁻⁷	3 x 10⁻¹¹	3 x 10⁻⁸
	Cf 252	S	6 x 10⁻¹¹	3 x 10⁻⁷	2 x 10⁻¹²	7 x 10⁻⁹
			3 x 10⁻¹⁰	9 x 10⁻⁷	1 x 10⁻¹¹	7 x 10⁻⁸
	Cf 253	S	8 x 10⁻¹⁰	4 x 10⁻⁶	3 x 10⁻¹¹	1 x 10⁻⁷
			8 x 10⁻⁹	4 x 10⁻⁶	2 x 10⁻¹⁰	1 x 10⁻⁷
	Cf 254	S	5 x 10⁻¹⁰	4 x 10⁻⁷	2 x 10⁻¹¹	1 x 10⁻⁸
			5 x 10⁻⁹	4 x 10⁻⁶	2 x 10⁻¹⁰	1 x 10⁻⁷
Carbon (6)	C 14 (CO)	Sub	4 x 10⁻⁶	2 x 10⁻²	1 x 10⁻⁷	8 x 10⁻⁴
			5 x 10⁻⁶		1 x 10⁻⁷	
Cerium (58)	Ce 141	S	4 x 10⁻⁷	3 x 10⁻⁴	2 x 10⁻⁸	9 x 10⁻⁶
			2 x 10⁻⁷	3 x 10⁻⁴	8 x 10⁻⁹	9 x 10⁻⁶
	Ce 143	S	2 x 10⁻⁷	1 x 10⁻⁴	9 x 10⁻⁹	4 x 10⁻⁶
			2 x 10⁻⁷	1 x 10⁻⁴	7 x 10⁻⁹	4 x 10⁻⁶
	Ce 144	S	1 x 10⁻⁷	3 x 10⁻⁵	3 x 10⁻⁹	1 x 10⁻⁶
			6 x 10⁻⁷	3 x 10⁻⁴	2 x 10⁻⁸	1 x 10⁻⁵
Cesium (55)	Cs 131	S	1 x 10⁻⁶	7 x 10⁻⁴	4 x 10⁻⁸	2 x 10⁻⁵
			3 x 10⁻⁶	9 x 10⁻⁴	1 x 10⁻⁷	9 x 10⁻⁵
	Cs 134m	S	4 x 10⁻⁶	2 x 10⁻²	1 x 10⁻⁷	6 x 10⁻⁴
			6 x 10⁻⁶	2 x 10⁻²	2 x 10⁻⁷	1 x 10⁻³
	Cs 134	S	4 x 10⁻⁸	2 x 10⁻⁵	1 x 10⁻⁹	9 x 10⁻⁷
			1 x 10⁻⁷	1 x 10⁻⁴	4 x 10⁻⁹	4 x 10⁻⁶
	Cs 135	S	5 x 10⁻⁸	3 x 10⁻⁵	2 x 10⁻⁹	1 x 10⁻⁶
			9 x 10⁻⁸	7 x 10⁻⁵	3 x 10⁻⁹	2 x 10⁻⁶
	Cs 136	S	4 x 10⁻⁷	2 x 10⁻⁴	1 x 10⁻⁸	9 x 10⁻⁶
			3 x 10⁻⁷	2 x 10⁻⁴	9 x 10⁻⁹	6 x 10⁻⁶
	Cs 137	S	6 x 10⁻⁸	4 x 10⁻⁵	2 x 10⁻⁹	1 x 10⁻⁶
			1 x 10⁻⁷	1 x 10⁻⁴	4 x 10⁻⁹	4 x 10⁻⁶
Chlorine (17)	Cl 36	S	4 x 10⁻⁷	2 x 10⁻⁴	1 x 10⁻⁸	6 x 10⁻⁶
			3 x 10⁻⁷	1 x 10⁻⁴	9 x 10⁻⁹	4 x 10⁻⁶
	Cl 38	S	2 x 10⁻⁷	1 x 10⁻⁴	7 x 10⁻⁹	4 x 10⁻⁶
			1 x 10⁻⁶	8 x 10⁻³	4 x 10⁻⁸	3 x 10⁻⁴
Chromium (24)	Cr 51	S	3 x 10⁻⁶	2 x 10⁻²	9 x 10⁻⁸	8 x 10⁻⁴

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	Column 2	Column 1	Column 2
			Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Cobalt (27)	Co 57	S	8×10^{-6}	3×10^{-5}	1×10^{-7}	3×10^{-7}
	Co 58m	S	2×10^{-5}	1×10^{-4}	6×10^{-7}	4×10^{-6}
	Co 58	S	3×10^{-6}	9×10^{-6}	9×10^{-8}	3×10^{-7}
	Co 60	S	9×10^{-7}	4×10^{-6}	3×10^{-8}	1×10^{-7}
	Co 60	W	9×10^{-7}	3×10^{-6}	3×10^{-8}	1×10^{-7}
	Co 60	D	3×10^{-7}	1×10^{-6}	1×10^{-8}	4×10^{-8}
	Co 60	Y	3×10^{-6}	1×10^{-5}	3×10^{-8}	1×10^{-7}
Copper (29)	Cu 64	S	3×10^{-5}	1×10^{-4}	1×10^{-6}	4×10^{-6}
	Cu 64	W	1×10^{-4}	6×10^{-4}	4×10^{-6}	2×10^{-5}
Curium (96)	Cm 242	W	1×10^{-10}	7×10^{-10}	4×10^{-12}	2×10^{-11}
	Cm 242	Y	3×10^{-9}	2×10^{-8}	6×10^{-11}	2×10^{-10}
	Cm 243	W	6×10^{-11}	1×10^{-10}	3×10^{-12}	4×10^{-12}
	Cm 243	Y	1×10^{-9}	7×10^{-9}	3×10^{-11}	2×10^{-10}
	Cm 244	W	1×10^{-10}	9×10^{-10}	4×10^{-12}	3×10^{-11}
	Cm 244	Y	2×10^{-9}	1×10^{-8}	6×10^{-11}	4×10^{-10}
	Cm 245	W	6×10^{-11}	1×10^{-10}	2×10^{-12}	4×10^{-12}
	Cm 245	Y	1×10^{-9}	8×10^{-9}	3×10^{-11}	2×10^{-10}
	Cm 246	W	6×10^{-11}	1×10^{-10}	2×10^{-12}	4×10^{-12}
	Cm 246	Y	1×10^{-9}	8×10^{-9}	3×10^{-11}	2×10^{-10}
	Cm 247	W	6×10^{-11}	1×10^{-10}	2×10^{-12}	4×10^{-12}
	Cm 247	Y	1×10^{-9}	8×10^{-9}	3×10^{-11}	2×10^{-10}
	Cm 248	W	2×10^{-11}	1×10^{-10}	6×10^{-13}	4×10^{-12}
	Cm 248	Y	1×10^{-10}	4×10^{-9}	2×10^{-12}	1×10^{-10}
	Cm 249	W	1×10^{-4}	6×10^{-4}	2×10^{-6}	2×10^{-5}
	Cm 249	Y	1×10^{-4}	6×10^{-4}	4×10^{-6}	2×10^{-5}
Dysprosium (66)	Dy 165	S	8×10^{-6}	3×10^{-5}	3×10^{-7}	1×10^{-6}
	Dy 165	W	3×10^{-6}	1×10^{-5}	7×10^{-8}	4×10^{-7}
	Dy 166	S	3×10^{-7}	1×10^{-6}	8×10^{-9}	4×10^{-8}
	Dy 166	W	3×10^{-7}	1×10^{-6}	7×10^{-9}	4×10^{-8}
Einsteinium (99)	Es 253	S	3×10^{-10}	2×10^{-9}	9×10^{-12}	6×10^{-11}
	Es 253	W	3×10^{-10}	2×10^{-9}	9×10^{-12}	6×10^{-11}
	Es 254m	S	3×10^{-8}	9×10^{-8}	2×10^{-9}	3×10^{-8}
	Es 254m	W	6×10^{-9}	2×10^{-8}	2×10^{-10}	6×10^{-10}
	Es 254	S	3×10^{-9}	1×10^{-8}	6×10^{-11}	4×10^{-10}
	Es 254	W	1×10^{-8}	4×10^{-8}	4×10^{-10}	1×10^{-9}
	Es 255	S	9×10^{-9}	3×10^{-8}	2×10^{-10}	1×10^{-9}
	Es 255	W	4×10^{-8}	1×10^{-7}	1×10^{-9}	5×10^{-9}
Erbium (68)	Er 169	S	4×10^{-7}	2×10^{-6}	1×10^{-8}	6×10^{-8}
	Er 171	S	4×10^{-7}	2×10^{-6}	1×10^{-8}	6×10^{-8}
Europium (63)	Eu 150 (T/2 = 9.2 hrs)	S	7×10^{-7}	3×10^{-6}	2×10^{-8}	1×10^{-7}
	Eu 150 (T/2 = 9.2 hrs)	W	6×10^{-7}	2×10^{-6}	2×10^{-8}	1×10^{-7}
	Eu 150 (T/2 = 34 yrs)	S	4×10^{-7}	2×10^{-6}	1×10^{-8}	6×10^{-8}
	Eu 150 (T/2 = 34 yrs)	W	3×10^{-7}	1×10^{-6}	1×10^{-8}	6×10^{-8}
	Eu 152 (T/2 = 13 yrs)	S	4×10^{-7}	2×10^{-6}	1×10^{-8}	6×10^{-8}
	Eu 152 (T/2 = 13 yrs)	W	3×10^{-7}	1×10^{-6}	1×10^{-8}	6×10^{-8}
	Eu 154	S	4×10^{-7}	2×10^{-6}	1×10^{-8}	6×10^{-8}
	Eu 154	W	3×10^{-7}	1×10^{-6}	1×10^{-8}	6×10^{-8}
	Eu 155	S	1×10^{-6}	5×10^{-6}	3×10^{-8}	2×10^{-7}
	Eu 155	W	1×10^{-6}	4×10^{-6}	3×10^{-8}	2×10^{-7}

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	Column 2	Column 1	Column 2
			Air	Water	Air	Water
			(μCi/ml)	(μCi/ml)	(μCi/ml)	(μCi/ml)
Promethium (61)	Pm 144	D	4 × 10⁻⁸	4 × 10⁻⁴	2 × 10⁻⁷	1 × 10⁻³
	Pm 145	W	6 × 10⁻⁸	6 × 10⁻⁴	3 × 10⁻⁷	1 × 10⁻³
	Pm 147	W	2 × 10⁻⁷	1 × 10⁻³	6 × 10⁻⁷	3 × 10⁻³
	Pm 148m	W	1 × 10⁻⁸	1 × 10⁻⁴	4 × 10⁻⁸	3 × 10⁻⁴
	Pm 149	W	3 × 10⁻⁸	3 × 10⁻⁴	1 × 10⁻⁷	9 × 10⁻⁴
	Pm 151	W	9 × 10⁻⁸	9 × 10⁻⁴	4 × 10⁻⁷	3 × 10⁻³
Samarium (62)	Sm 147	W	2 × 10⁻⁸	2 × 10⁻⁴	8 × 10⁻⁸	6 × 10⁻⁴
	Sm 151	W	3 × 10⁻⁷	1 × 10⁻³	9 × 10⁻⁷	3 × 10⁻³
	Sm 153	W	9 × 10⁻⁸	9 × 10⁻⁴	3 × 10⁻⁷	3 × 10⁻³
Europium (63)	Eu 152	W	6 × 10⁻⁸	6 × 10⁻⁴	2 × 10⁻⁷	2 × 10⁻³
	Eu 154	W	4 × 10⁻⁸	4 × 10⁻⁴	1 × 10⁻⁷	1 × 10⁻³
	Eu 155	W	3 × 10⁻⁷	1 × 10⁻³	9 × 10⁻⁷	3 × 10⁻³
Gadolinium (64)	Gd 153	W	2 × 10⁻⁷	1 × 10⁻³	6 × 10⁻⁷	3 × 10⁻³
	Gd 159	W	8 × 10⁻⁸	8 × 10⁻⁴	3 × 10⁻⁷	3 × 10⁻³
Terbium (65)	Tb 160	W	2 × 10⁻⁸	2 × 10⁻⁴	8 × 10⁻⁸	6 × 10⁻⁴
Dysprosium (66)	Dy 165	W	4 × 10⁻⁷	2 × 10⁻³	1 × 10⁻⁶	6 × 10⁻³
	Dy 166	W	6 × 10⁻⁸	6 × 10⁻⁴	2 × 10⁻⁷	2 × 10⁻³
Holmium (67)	Ho 166	W	3 × 10⁻⁸	3 × 10⁻⁴	1 × 10⁻⁷	9 × 10⁻⁴
Erbium (68)	Er 169	W	1 × 10⁻⁷	1 × 10⁻³	4 × 10⁻⁷	3 × 10⁻³
	Er 171	W	8 × 10⁻⁸	8 × 10⁻⁴	3 × 10⁻⁷	3 × 10⁻³
Thulium (69)	Tm 170	W	1 × 10⁻⁷	1 × 10⁻³	4 × 10⁻⁷	3 × 10⁻³
	Tm 171	W	1 × 10⁻⁶	1 × 10⁻²	4 × 10⁻⁶	3 × 10⁻²
Ytterbium (70)	Yb 175	W	3 × 10⁻⁷	1 × 10⁻³	1 × 10⁻⁶	3 × 10⁻³
Lutetium (71)	Lu 177	W	2 × 10⁻⁷	1 × 10⁻³	6 × 10⁻⁷	3 × 10⁻³
Hafnium (72)	Hf 181	W	2 × 10⁻⁸	2 × 10⁻⁴	6 × 10⁻⁸	6 × 10⁻⁴
Tantalum (73)	Ta 182	W	4 × 10⁻⁹	4 × 10⁻⁵	1 × 10⁻⁸	1 × 10⁻⁴
Tungsten (74)	W 181	W	3 × 10⁻⁷	3 × 10⁻³	1 × 10⁻⁶	9 × 10⁻³
	W 185	W	1 × 10⁻⁶	1 × 10⁻²	4 × 10⁻⁶	3 × 10⁻²
	W 187	W	6 × 10⁻⁸	6 × 10⁻⁴	2 × 10⁻⁷	2 × 10⁻³
Rhenium (75)	Re 183	W	3 × 10⁻⁷	3 × 10⁻³	1 × 10⁻⁶	9 × 10⁻³
	Re 186	W	9 × 10⁻⁸	9 × 10⁻⁴	3 × 10⁻⁷	3 × 10⁻³
	Re 188	W	3 × 10⁻⁸	3 × 10⁻⁴	1 × 10⁻⁷	9 × 10⁻⁴
Osmium (76)	Os 185	W	2 × 10⁻⁷	1 × 10⁻³	6 × 10⁻⁷	3 × 10⁻³
	Os 191	W	2 × 10⁻⁷	1 × 10⁻³	6 × 10⁻⁷	3 × 10⁻³
	Os 191m	W	3 × 10⁻⁶	3 × 10⁻²	1 × 10⁻⁵	9 × 10⁻²
	Os 193	W	1 × 10⁻⁷	6 × 10⁻⁴	4 × 10⁻⁷	2 × 10⁻³
Iridium (77)	Ir 190	W	2 × 10⁻⁷	1 × 10⁻³	6 × 10⁻⁷	3 × 10⁻³
	Ir 192	W	3 × 10⁻⁸	3 × 10⁻⁴	1 × 10⁻⁷	9 × 10⁻⁴
	Ir 194	W	2 × 10⁻⁷	1 × 10⁻³	6 × 10⁻⁷	3 × 10⁻³
Platinum (78)	Pt 191	W	1 × 10⁻⁷	1 × 10⁻³	4 × 10⁻⁷	3 × 10⁻³
	Pt 193m	W	1 × 10⁻⁶	1 × 10⁻²	4 × 10⁻⁶	3 × 10⁻²
	Pt 197	W	1 × 10⁻⁶	1 × 10⁻²	4 × 10⁻⁶	3 × 10⁻²
	Pt 197m	W	1 × 10⁻⁶	1 × 10⁻²	4 × 10⁻⁶	3 × 10⁻²
Gold (79)	Au 198	W	2 × 10⁻⁷	1 × 10⁻³	6 × 10⁻⁷	3 × 10⁻³
	Au 199	W	2 × 10⁻⁷	1 × 10⁻³	6 × 10⁻⁷	3 × 10⁻³
Mercury (80)	Hg 197	W	3 × 10⁻⁷	3 × 10⁻³	1 × 10⁻⁶	9 × 10⁻³
	Hg 197m	W	2 × 10⁻⁷	1 × 10⁻³	6 × 10⁻⁷	3 × 10⁻³
	Hg 203	W	6 × 10⁻⁸	6 × 10⁻⁴	2 × 10⁻⁷	2 × 10⁻³
Thallium (81)	Tl 200	W	4 × 10⁻⁸	4 × 10⁻⁴	1 × 10⁻⁷	1 × 10⁻³
	Tl 201	W	1 × 10⁻⁷	1 × 10⁻³	4 × 10⁻⁷	3 × 10⁻³
	Tl 202	W	1 × 10⁻⁷	1 × 10⁻³	4 × 10⁻⁷	3 × 10⁻³
	Tl 204	W	1 × 10⁻⁶	1 × 10⁻²	4 × 10⁻⁶	3 × 10⁻²
Lead (82)	Pb 203	W	4 × 10⁻⁷	4 × 10⁻³	1 × 10⁻⁶	1 × 10⁻²
Bismuth (83)	Bi 205	W	5 × 10⁻⁸	5 × 10⁻⁴	2 × 10⁻⁷	2 × 10⁻³
	Bi 206	W	3 × 10⁻⁸	3 × 10⁻⁴	1 × 10⁻⁷	9 × 10⁻⁴
Polonium (84)	Po 203	W	6 × 10⁻⁸	6 × 10⁻⁴	2 × 10⁻⁷	2 × 10⁻³
	Po 205	W	6 × 10⁻⁸	6 × 10⁻⁴	2 × 10⁻⁷	2 × 10⁻³
	Po 207	W	4 × 10⁻⁸	4 × 10⁻⁴	1 × 10⁻⁷	1 × 10⁻³
Astatine (85)	At 211	W	2 × 10⁻⁷	1 × 10⁻³	6 × 10⁻⁷	3 × 10⁻³
Francium (87)	Fr 222	W	2 × 10⁻⁸	2 × 10⁻⁴	6 × 10⁻⁸	6 × 10⁻⁴
Radium (88)	Ra 223	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Ra 224	W	3 × 10⁻⁹	3 × 10⁻⁵	1 × 10⁻⁸	9 × 10⁻⁵
	Ra 226	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Ra 228	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
Actinium (89)	Ac 225	W	2 × 10⁻⁸	2 × 10⁻⁴	6 × 10⁻⁸	6 × 10⁻⁴
	Ac 227	W	1 × 10⁻¹⁰	1 × 10⁻⁶	4 × 10⁻¹⁰	3 × 10⁻⁶
	Ac 228	W	3 × 10⁻⁸	3 × 10⁻⁴	1 × 10⁻⁷	9 × 10⁻⁴
Thorium (90)	Th 226	W	2 × 10⁻⁷	2 × 10⁻³	6 × 10⁻⁷	6 × 10⁻³
	Th 227	W	1 × 10⁻⁸	1 × 10⁻⁴	4 × 10⁻⁸	3 × 10⁻⁴
	Th 228	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Th 229	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Th 230	W	1 × 10⁻⁸	1 × 10⁻⁴	4 × 10⁻⁸	3 × 10⁻⁴
	Th 231	W	3 × 10⁻⁷	3 × 10⁻³	1 × 10⁻⁶	9 × 10⁻³
	Th 232	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Th 234	W	3 × 10⁻⁷	3 × 10⁻³	1 × 10⁻⁶	9 × 10⁻³
Protactinium (91)	Pa 230	W	2 × 10⁻⁸	2 × 10⁻⁴	6 × 10⁻⁸	6 × 10⁻⁴
	Pa 231	W	1 × 10⁻¹⁰	1 × 10⁻⁶	4 × 10⁻¹⁰	3 × 10⁻⁶
	Pa 233	W	2 × 10⁻⁸	2 × 10⁻⁴	6 × 10⁻⁸	6 × 10⁻⁴
Uranium (92)	U 230	W	2 × 10⁻⁸	2 × 10⁻⁴	6 × 10⁻⁸	6 × 10⁻⁴
	U 231	W	2 × 10⁻⁷	2 × 10⁻³	6 × 10⁻⁷	6 × 10⁻³
	U 232	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	U 233	W	1 × 10⁻⁸	1 × 10⁻⁴	4 × 10⁻⁸	3 × 10⁻⁴
	U 234	W	1 × 10⁻⁸	1 × 10⁻⁴	4 × 10⁻⁸	3 × 10⁻⁴
	U 235	W	1 × 10⁻⁸	1 × 10⁻⁴	4 × 10⁻⁸	3 × 10⁻⁴
	U 236	W	1 × 10⁻⁸	1 × 10⁻⁴	4 × 10⁻⁸	3 × 10⁻⁴
	U 238	W	1 × 10⁻⁸	1 × 10⁻⁴	4 × 10⁻⁸	3 × 10⁻⁴
	U 240	W	3 × 10⁻⁷	3 × 10⁻³	1 × 10⁻⁶	9 × 10⁻³
Neptunium (93)	Np 232	W	2 × 10⁻⁸	2 × 10⁻⁴	6 × 10⁻⁸	6 × 10⁻⁴
	Np 233	W	2 × 10⁻⁷	2 × 10⁻³	6 × 10⁻⁷	6 × 10⁻³
	Np 234	W	2 × 10⁻⁸	2 × 10⁻⁴	6 × 10⁻⁸	6 × 10⁻⁴
	Np 235	W	1 × 10⁻⁷	1 × 10⁻³	4 × 10⁻⁷	3 × 10⁻³
	Np 236	W	1 × 10⁻⁸	1 × 10⁻⁴	4 × 10⁻⁸	3 × 10⁻⁴
	Np 236	W	2 × 10⁻⁸	2 × 10⁻⁴	6 × 10⁻⁸	6 × 10⁻⁴
	Np 237	W	1 × 10⁻⁸	1 × 10⁻⁴	4 × 10⁻⁸	3 × 10⁻⁴
	Np 239	W	1 × 10⁻⁷	1 × 10⁻³	4 × 10⁻⁷	3 × 10⁻³
	Np 240	W	4 × 10⁻⁸	4 × 10⁻⁴	1 × 10⁻⁷	1 × 10⁻³
Plutonium (94)	Pu 234	W	2 × 10⁻⁸	2 × 10⁻⁴	6 × 10⁻⁸	6 × 10⁻⁴
	Pu 235	W	2 × 10⁻⁷	2 × 10⁻³	6 × 10⁻⁷	6 × 10⁻³
	Pu 236	W	1 × 10⁻⁸	1 × 10⁻⁴	4 × 10⁻⁸	3 × 10⁻⁴
	Pu 237	W	2 × 10⁻⁷	2 × 10⁻³	6 × 10⁻⁷	6 × 10⁻³
	Pu 238	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Pu 239	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Pu 240	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Pu 241	W	4 × 10⁻⁸	4 × 10⁻⁴	1 × 10⁻⁷	1 × 10⁻³
	Pu 242	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Pu 244	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
Americium (95)	Am 241	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Am 242m	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Am 243	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
Curium (96)	Cm 242	W	1 × 10⁻⁸	1 × 10⁻⁴	4 × 10⁻⁸	3 × 10⁻⁴
	Cm 243	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Cm 244	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Cm 245	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Cm 246	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Cm 247	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Cm 248	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
Berkelium (97)	Bk 249	W	2 × 10⁻⁷	2 × 10⁻³	6 × 10⁻⁷	6 × 10⁻³
Californium (98)	Cf 249	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Cf 250	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Cf 251	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Cf 252	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵
	Cf 254	W	1 × 10⁻⁹	1 × 10⁻⁵	4 × 10⁻⁹	3 × 10⁻⁵

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	Column 2 Water	Column 1 Air	Column 2 Water
			(μCi/ml)	(μCi/ml)	(μCi/ml)	(μCi/ml)
Iodine (53)	I 125	I	2×10^{-9}	2×10^{-5}	1×10^{-7}	6×10^{-9}
	I 126	I	1×10^{-9}	7×10^{-6}	1×10^{-8}	4×10^{-8}
		D	6×10^{-9}	2×10^{-5}	1×10^{-7}	7×10^{-9}
Iodine (77)	I 130	I	1×10^{-8}	6×10^{-6}	4×10^{-8}	2×10^{-7}
		D	4×10^{-9}	2×10^{-6}	1×10^{-7}	2×10^{-7}
	I 131	I	1×10^{-9}	1×10^{-6}	4×10^{-8}	4×10^{-8}
		D	8×10^{-9}	1×10^{-6}	9×10^{-10}	4×10^{-8}
	I 132	I	2×10^{-9}	1×10^{-6}	8×10^{-8}	3×10^{-7}
		D	2×10^{-7}	9×10^{-7}	8×10^{-8}	3×10^{-7}
Iron (26)	Fe 55	D	9×10^{-7}	2×10^{-4}	3×10^{-6}	8×10^{-7}
		W	1×10^{-9}	7×10^{-7}	3×10^{-8}	3×10^{-7}
	Fe 59	D	1×10^{-7}	3×10^{-7}	5×10^{-7}	6×10^{-7}
		W	8×10^{-9}	3×10^{-7}	3×10^{-7}	8×10^{-7}
Krypton (36)	Kr 85m	Sub	6×10^{-6}	.....	1×10^{-7}	.....
	Kr 85	Sub	1×10^{-5}	.....	3×10^{-7}	.....
	Kr 87	Sub	1×10^{-6}	.....	2×10^{-8}	.....
	Kr 88	Sub	1×10^{-6}	.....	2×10^{-8}	.....
Lanthanum (57)	La 140	D	2×10^{-7}	7×10^{-6}	5×10^{-7}	2×10^{-7}
		W	1×10^{-7}	7×10^{-6}	4×10^{-8}	2×10^{-7}
Lead (82)	Pb 203	D	3×10^{-6}	1×10^{-4}	9×10^{-7}	4×10^{-7}
		W	2×10^{-6}	1×10^{-4}	6×10^{-8}	4×10^{-7}
	Pb 210	D	1×10^{-10}	4×10^{-9}	4×10^{-10}	1×10^{-7}
		W	2×10^{-10}	3×10^{-9}	9×10^{-10}	9×10^{-9}
	Pb 212	D	2×10^{-6}	6×10^{-6}	6×10^{-10}	2×10^{-7}
		W	2×10^{-6}	8×10^{-6}	7×10^{-10}	2×10^{-7}
Lutetium (71)	Lu 177	D	6×10^{-7}	3×10^{-6}	2×10^{-8}	1×10^{-7}
		W	5×10^{-7}	3×10^{-6}	2×10^{-8}	1×10^{-7}
Manganese (25)	Mn 52	D	2×10^{-7}	1×10^{-6}	7×10^{-9}	3×10^{-7}
		W	1×10^{-7}	9×10^{-7}	5×10^{-8}	3×10^{-7}
	Mn 54	D	4×10^{-7}	4×10^{-6}	1×10^{-8}	1×10^{-7}
		W	4×10^{-8}	3×10^{-6}	1×10^{-7}	1×10^{-7}
	Mn 56	D	6×10^{-7}	4×10^{-6}	3×10^{-8}	1×10^{-7}
		W	5×10^{-7}	3×10^{-6}	2×10^{-8}	1×10^{-7}
Mercury (80)	Hg 197m	D	7×10^{-7}	2×10^{-6}	2×10^{-8}	2×10^{-7}
		W	6×10^{-7}	8×10^{-7}	2×10^{-8}	2×10^{-7}
	Hg 197	D	1×10^{-6}	9×10^{-6}	4×10^{-8}	3×10^{-7}
		W	9×10^{-9}	1×10^{-6}	9×10^{-9}	3×10^{-7}
	Hg 203	D	7×10^{-9}	8×10^{-7}	2×10^{-8}	9×10^{-8}
		W	1×10^{-7}	3×10^{-6}	4×10^{-8}	1×10^{-7}
Molybdenum (42)	Mo 99	D	7×10^{-7}	3×10^{-6}	3×10^{-8}	2×10^{-7}
		W	2×10^{-7}	1×10^{-6}	7×10^{-9}	4×10^{-8}
Neodymium (60)	Nd 144	D	8×10^{-11}	2×10^{-7}	2×10^{-11}	7×10^{-9}
		W	2×10^{-10}	2×10^{-7}	1×10^{-11}	8×10^{-9}
	Nd 147	D	4×10^{-7}	2×10^{-6}	1×10^{-8}	6×10^{-8}
		W	2×10^{-7}	2×10^{-6}	8×10^{-9}	6×10^{-8}
	Nd 149	D	2×10^{-6}	8×10^{-6}	6×10^{-8}	3×10^{-7}
		W	1×10^{-6}	6×10^{-6}	5×10^{-8}	3×10^{-7}

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	Column 2	Column 1	Column 2
			Air (μCi/ml)	Water (μCi)	Air (μCi/ml)	Water (μCi)
Hydrogen (1)	H-3	S	6×10^{-6}	9×10^{-2}	1×10^{-6}	3×10^{-3}
	H-3	W	1×10^{-6}	9×10^{-2}	4×10^{-6}	3×10^{-3}
Beryllium (4)	Be-7	W	6×10^{-7}	4×10^{-3}	2×10^{-6}	1×10^{-4}
	Be-7	Y	7×10^{-7}	4×10^{-3}	2×10^{-6}	1×10^{-4}
	Be-10	W	8×10^{-7}	6×10^{-4}	3×10^{-6}	2×10^{-5}
	Be-10	Y	8×10^{-7}	6×10^{-4}	3×10^{-6}	2×10^{-5}
Carbon (6)	C-14	W	6×10^{-7}	6×10^{-4}	3×10^{-6}	2×10^{-5}
	C-14	Y	6×10^{-7}	6×10^{-4}	3×10^{-6}	2×10^{-5}
Fluorine (9)	F-18	W	3×10^{-7}	2×10^{-3}	1×10^{-6}	7×10^{-5}
	F-18	Y	9×10^{-7}	6×10^{-3}	3×10^{-6}	2×10^{-4}
Sodium (11)	Na-22	W	8×10^{-7}	5×10^{-3}	3×10^{-6}	2×10^{-4}
	Na-22	Y	1×10^{-7}	1×10^{-3}	6×10^{-6}	4×10^{-5}
Magnesium (12)	Mg-28	W	2×10^{-7}	1×10^{-3}	6×10^{-6}	4×10^{-5}
	Mg-28	Y	8×10^{-7}	5×10^{-3}	3×10^{-6}	2×10^{-4}
Aluminum (13)	Al-26	W	1×10^{-7}	8×10^{-4}	3×10^{-6}	2×10^{-5}
	Al-26	Y	6×10^{-8}	3×10^{-4}	2×10^{-6}	1×10^{-5}
Silicon (14)	Si-31	W	3×10^{-6}	2×10^{-2}	1×10^{-5}	7×10^{-5}
	Si-31	Y	3×10^{-6}	2×10^{-2}	1×10^{-5}	7×10^{-5}
Phosphorus (15)	P-32	W	2×10^{-7}	1×10^{-3}	6×10^{-6}	4×10^{-5}
	P-32	Y	2×10^{-7}	1×10^{-3}	6×10^{-6}	4×10^{-5}
Sulfur (16)	S-35	W	2×10^{-6}	1×10^{-2}	6×10^{-6}	4×10^{-5}
	S-35	Y	2×10^{-6}	1×10^{-2}	6×10^{-6}	4×10^{-5}
Chlorine (17)	Cl-36	W	2×10^{-7}	1×10^{-3}	6×10^{-6}	4×10^{-5}
	Cl-36	Y	2×10^{-7}	1×10^{-3}	6×10^{-6}	4×10^{-5}
Potassium (19)	K-42	W	3×10^{-7}	2×10^{-3}	1×10^{-6}	7×10^{-5}
	K-42	Y	3×10^{-7}	2×10^{-3}	1×10^{-6}	7×10^{-5}
	K-43	W	1×10^{-7}	8×10^{-4}	4×10^{-6}	3×10^{-5}
	K-43	Y	1×10^{-7}	8×10^{-4}	4×10^{-6}	3×10^{-5}
Calcium (20)	Ca-45	W	2×10^{-7}	1×10^{-3}	6×10^{-6}	4×10^{-5}
	Ca-45	Y	2×10^{-7}	1×10^{-3}	6×10^{-6}	4×10^{-5}
	Ca-47	W	1×10^{-7}	9×10^{-4}	3×10^{-6}	3×10^{-5}
	Ca-47	Y	1×10^{-7}	9×10^{-4}	3×10^{-6}	3×10^{-5}
Scandium (21)	Sc-46	W	3×10^{-7}	2×10^{-3}	1×10^{-6}	7×10^{-5}
	Sc-46	Y	3×10^{-7}	2×10^{-3}	1×10^{-6}	7×10^{-5}
	Sc-47	W	1×10^{-6}	9×10^{-4}	4×10^{-6}	3×10^{-5}
	Sc-47	Y	1×10^{-6}	9×10^{-4}	4×10^{-6}	3×10^{-5}
	Sc-48	W	4×10^{-7}	3×10^{-3}	1×10^{-6}	9×10^{-5}
	Sc-48	Y	4×10^{-7}	3×10^{-3}	1×10^{-6}	9×10^{-5}
Titanium (22)	Ti-44	W	1×10^{-7}	8×10^{-4}	3×10^{-6}	2×10^{-5}
	Ti-44	Y	1×10^{-7}	8×10^{-4}	3×10^{-6}	2×10^{-5}
Vanadium (23)	V-48	W	3×10^{-7}	2×10^{-3}	1×10^{-6}	7×10^{-5}
	V-48	Y	3×10^{-7}	2×10^{-3}	1×10^{-6}	7×10^{-5}
	V-49	W	2×10^{-6}	2×10^{-2}	7×10^{-6}	6×10^{-5}
	V-49	Y	2×10^{-6}	2×10^{-2}	7×10^{-6}	6×10^{-5}
Chromium (24)	Cr-48	W	2×10^{-6}	1×10^{-2}	7×10^{-6}	5×10^{-5}
	Cr-48	Y	2×10^{-6}	1×10^{-2}	7×10^{-6}	5×10^{-5}
	Cr-49	W	1×10^{-6}	9×10^{-4}	4×10^{-6}	3×10^{-5}
	Cr-49	Y	1×10^{-6}	9×10^{-4}	4×10^{-6}	3×10^{-5}
	Cr-51	W	2×10^{-6}	2×10^{-2}	7×10^{-6}	5×10^{-5}
	Cr-51	Y	2×10^{-6}	2×10^{-2}	7×10^{-6}	5×10^{-5}
Manganese (25)	Mn-51	W	1×10^{-6}	9×10^{-4}	4×10^{-6}	3×10^{-5}
	Mn-51	Y	1×10^{-6}	9×10^{-4}	4×10^{-6}	3×10^{-5}
	Mn-52	W	3×10^{-7}	2×10^{-3}	1×10^{-6}	7×10^{-5}
	Mn-52	Y	3×10^{-7}	2×10^{-3}	1×10^{-6}	7×10^{-5}
	Mn-52m	W	1×10^{-6}	1×10^{-3}	5×10^{-6}	4×10^{-5}
	Mn-52m	Y	1×10^{-6}	1×10^{-3}	5×10^{-6}	4×10^{-5}
	Mn-53	W	1×10^{-5}	1×10^{-2}	4×10^{-5}	3×10^{-4}
	Mn-53	Y	1×10^{-5}	1×10^{-2}	4×10^{-5}	3×10^{-4}
	Mn-54	W	4×10^{-7}	3×10^{-3}	1×10^{-6}	9×10^{-5}
	Mn-54	Y	4×10^{-7}	3×10^{-3}	1×10^{-6}	9×10^{-5}
	Mn-56	W	1×10^{-6}	9×10^{-4}	4×10^{-6}	3×10^{-5}
	Mn-56	Y	1×10^{-6}	9×10^{-4}	4×10^{-6}	3×10^{-5}
Iron (26)	Fe-52	W	3×10^{-7}	2×10^{-3}	1×10^{-6}	7×10^{-5}
	Fe-52	Y	3×10^{-7}	2×10^{-3}	1×10^{-6}	7×10^{-5}
	Fe-55	W	8×10^{-7}	6×10^{-3}	3×10^{-6}	2×10^{-4}
	Fe-55	Y	8×10^{-7}	6×10^{-3}	3×10^{-6}	2×10^{-4}
	Fe-59	W	2×10^{-7}	1×10^{-3}	6×10^{-6}	4×10^{-5}
	Fe-59	Y	2×10^{-7}	1×10^{-3}	6×10^{-6}	4×10^{-5}
	Fe-60	W	2×10^{-8}	1×10^{-4}	6×10^{-7}	4×10^{-6}
	Fe-60	Y	2×10^{-8}	1×10^{-4}	6×10^{-7}	4×10^{-6}
Cobalt (27)	Co-55	W	1×10^{-6}	9×10^{-4}	4×10^{-6}	3×10^{-5}
	Co-55	Y	1×10^{-6}	9×10^{-4}	4×10^{-6}	3×10^{-5}
	Co-56	W	3×10^{-7}	2×10^{-3}	1×10^{-6}	7×10^{-5}
	Co-56	Y	3×10^{-7}	2×10^{-3}	1×10^{-6}	7×10^{-5}
	Co-57	W	2×10^{-6}	2×10^{-2}	7×10^{-6}	5×10^{-5}
	Co-57	Y	2×10^{-6}	2×10^{-2}	7×10^{-6}	5×10^{-5}
	Co-58	W	1×10^{-6}	9×10^{-4}	4×10^{-6}	3×10^{-5}
	Co-58	Y	1×10^{-6}	9×10^{-4}	4×10^{-6}	3×10^{-5}
	Co-58m	W	2×10^{-5}	2×10^{-2}	7×10^{-5}	5×10^{-4}
	Co-58m	Y	2×10^{-5}	2×10^{-2}	7×10^{-5}	5×10^{-4}
	Co-60	W	4×10^{-7}	3×10^{-3}	1×10^{-6}	9×10^{-5}
	Co-60	Y	4×10^{-7}	3×10^{-3}	1×10^{-6}	9×10^{-5}
	Co-60m	W	1×10^{-5}	1×10^{-2}	4×10^{-5}	3×10^{-4}
	Co-60m	Y	1×10^{-5}	1×10^{-2}	4×10^{-5}	3×10^{-4}
	Co-61	W	1×10^{-6}	1×10^{-2}	4×10^{-6}	3×10^{-5}
	Co-61	Y	1×10^{-6}	1×10^{-2}	4×10^{-6}	3×10^{-5}
	Co-62m	W	3×10^{-6}	3×10^{-2}	1×10^{-5}	9×10^{-5}
	Co-62m	Y	3×10^{-6}	3×10^{-2}	1×10^{-5}	9×10^{-5}
Nickel (28)	Ni-56	W	3×10^{-7}	2×10^{-3}	1×10^{-6}	7×10^{-5}
	Ni-56	Y	3×10^{-7}	2×10^{-3}	1×10^{-6}	7×10^{-5}
	Ni-57	W	2×10^{-7}	1×10^{-3}	6×10^{-6}	4×10^{-5}
	Ni-57	Y	2×10^{-7}	1×10^{-3}	6×10^{-6}	4×10^{-5}
	Ni-59	W	8×10^{-7}	6×10^{-3}	3×10^{-6}	2×10^{-4}
	Ni-59	Y	8×10^{-7}	6×10^{-3}	3×10^{-6}	2×10^{-4}
	Ni-63	W	3×10^{-7}	2×10^{-3}	1×10^{-6}	7×10^{-5}
	Ni-63	Y	3×10^{-7}	2×10^{-3}	1×10^{-6}	7×10^{-5}
	Ni-65	W	1×10^{-6}	9×10^{-4}	4×10^{-6}	3×10^{-5}
	Ni-65	Y	1×10^{-6}	9×10^{-4}	4×10^{-6}	3×10^{-5}
	Ni-66	W	2×10^{-7}	1×10^{-3}	6×10^{-6}	4×10^{-5}
	Ni-66	Y	2×10^{-7}	1×10^{-3}	6×10^{-6}	4×10^{-5}
Copper (29)	Cu-60	W	1×10^{-6}	9×10^{-4}	4×10^{-6}	3×10^{-5}
	Cu-60	Y	1×10^{-6}	9×10^{-4}	4×10^{-6}	3×10^{-5}
	Cu-61	W	3×10^{-6}	2×10^{-2}	1×10^{-5}	7×10^{-5}
	Cu-61	Y	3×10^{-6}	2×10^{-2}	1×10^{-5}	7×10^{-5}
	Cu-64	W	1×10^{-6}	1×10^{-2}	4×10^{-6}	3×10^{-5}
	Cu-64	Y	1×10^{-6}	1×10^{-2}	4×10^{-6}	3×10^{-5}
	Cu-67	W	4×10^{-7}	3×10^{-3}	1×10^{-6}	9×10^{-5}
	Cu-67	Y	4×10^{-7}	3×10^{-3}	1×10^{-6}	9×10^{-5}

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	Column 2	Column 1	Column 2
			Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Polonium (84)	Po 205	S	9×10^{-11}	1×10^{-3}	6×10^{-11}	9×10^{-4}
	Po 206	S	4×10^{-11}	9×10^{-4}	1×10^{-10}	9×10^{-4}
	Po 207	S	8×10^{-9}	1×10^{-3}	6×10^{-9}	8×10^{-4}
	Po 208	S	2×10^{-9}	1×10^{-4}	9×10^{-9}	8×10^{-5}
	Po 209	S	2×10^{-9}	1×10^{-4}	6×10^{-9}	9×10^{-5}
	Po 210	S	8×10^{-11}	8×10^{-5}	1×10^{-10}	1×10^{-4}
Astatine (85)	At 211	S	2×10^{-9}	2×10^{-4}	9×10^{-11}	7×10^{-5}
	At 212	S	3×10^{-9}	8×10^{-4}	7×10^{-9}	9×10^{-4}
Francium (87)	Fr 222	S	2×10^{-9}	9×10^{-5}	7×10^{-9}	9×10^{-5}
	Fr 223	S	1×10^{-9}	6×10^{-5}	4×10^{-9}	8×10^{-5}
Radium (88)	Ra 223	W	8×10^{-11}	9×10^{-5}	7×10^{-9}	8×10^{-5}
	Ra 224	W	2×10^{-9}	1×10^{-4}	1×10^{-9}	8×10^{-5}
	Ra 225	W	8×10^{-11}	1×10^{-4}	6×10^{-11}	8×10^{-5}
	Ra 226	W	2×10^{-9}	1×10^{-4}	6×10^{-9}	8×10^{-5}
	Ra 228	W	6×10^{-11}	2×10^{-5}	4×10^{-11}	4×10^{-6}
Actinium (89)	Ac 224	S	2×10^{-9}	2×10^{-4}	9×10^{-11}	2×10^{-5}
	Ac 225	S	9×10^{-11}	7×10^{-5}	5×10^{-11}	9×10^{-6}
	Ac 226	S	1×10^{-9}	9×10^{-5}	6×10^{-9}	1×10^{-5}
	Ac 227	S	9×10^{-13}	9×10^{-7}	6×10^{-13}	7×10^{-7}
	Ac 228	S	3×10^{-9}	1×10^{-4}	6×10^{-9}	4×10^{-5}
Thorium (90)	Th 226	W	7×10^{-9}	9×10^{-5}	4×10^{-9}	9×10^{-5}
	Th 227	W	8×10^{-11}	6×10^{-5}	5×10^{-11}	9×10^{-5}
	Th 228	W	8×10^{-13}	9×10^{-7}	5×10^{-13}	9×10^{-7}
	Th 229	W	7×10^{-13}	8×10^{-7}	1×10^{-12}	8×10^{-7}
	Th 230	W	4×10^{-13}	7×10^{-7}	1×10^{-12}	8×10^{-7}
Protactinium (91)	Pa 230	W	9×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Pa 231	W	4×10^{-13}	9×10^{-7}	1×10^{-12}	9×10^{-7}
	Pa 233	W	1×10^{-9}	9×10^{-5}	1×10^{-9}	1×10^{-5}
Uranium (92)	U 230	W	2×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	U 231	W	2×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	U 232	W	2×10^{-13}	1×10^{-7}	1×10^{-13}	1×10^{-7}
	U 233	W	6×10^{-13}	3×10^{-7}	2×10^{-13}	3×10^{-7}
	U 234	W	6×10^{-13}	3×10^{-7}	2×10^{-13}	3×10^{-7}
	U 235	W	7×10^{-13}	3×10^{-7}	2×10^{-13}	3×10^{-7}
	U 236	W	6×10^{-13}	3×10^{-7}	2×10^{-13}	3×10^{-7}
	U 238	W	7×10^{-13}	3×10^{-7}	2×10^{-13}	3×10^{-7}
	U Nat	W	7×10^{-13}	3×10^{-7}	2×10^{-13}	3×10^{-7}
Neptunium (93)	Np 232	W	1×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Np 233	W	1×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Np 234	W	1×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Np 235	W	2×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Np 236 (1.2E+5 y)	W	2×10^{-11}	1×10^{-5}	1×10^{-11}	1×10^{-6}
	Np 236 (22.5 h)	W	2×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Np 237	W	2×10^{-13}	1×10^{-7}	1×10^{-13}	1×10^{-7}
	Np 239	W	1×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
Plutonium (94)	Pu 236	W	2×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Pu 237	W	2×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Pu 238	W	2×10^{-13}	1×10^{-7}	1×10^{-13}	1×10^{-7}
	Pu 239	W	2×10^{-13}	1×10^{-7}	1×10^{-13}	1×10^{-7}
	Pu 240	W	2×10^{-13}	1×10^{-7}	1×10^{-13}	1×10^{-7}
	Pu 241	W	6×10^{-11}	3×10^{-5}	2×10^{-11}	3×10^{-6}
	Pu 242	W	2×10^{-13}	1×10^{-7}	1×10^{-13}	1×10^{-7}
	Pu 243	W	1×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Pu 244	W	2×10^{-13}	1×10^{-7}	1×10^{-13}	1×10^{-7}
Americium (95)	Am 237	W	1×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Am 238	W	1×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Am 239	W	1×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Am 240	W	2×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Am 241	W	2×10^{-13}	1×10^{-7}	1×10^{-13}	1×10^{-7}
	Am 242	W	2×10^{-13}	1×10^{-7}	1×10^{-13}	1×10^{-7}
	Am 242m	W	2×10^{-13}	1×10^{-7}	1×10^{-13}	1×10^{-7}
	Am 243	W	2×10^{-13}	1×10^{-7}	1×10^{-13}	1×10^{-7}
	Am 244	W	1×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Am 244m	W	1×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Am 245	W	1×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Am 246	W	1×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Am 246m	W	1×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
Curium (96)	Cm 238	W	2×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Cm 240	W	2×10^{-13}	1×10^{-7}	1×10^{-13}	1×10^{-7}
	Cm 241	W	2×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Cm 242	W	2×10^{-11}	1×10^{-5}	1×10^{-11}	1×10^{-6}
	Cm 243	W	2×10^{-13}	1×10^{-7}	1×10^{-13}	1×10^{-7}
	Cm 244	W	2×10^{-13}	1×10^{-7}	1×10^{-13}	1×10^{-7}
	Cm 245	W	2×10^{-13}	1×10^{-7}	1×10^{-13}	1×10^{-7}
	Cm 246	W	2×10^{-13}	1×10^{-7}	1×10^{-13}	1×10^{-7}
	Cm 247	W	2×10^{-13}	1×10^{-7}	1×10^{-13}	1×10^{-7}
	Cm 248	W	5×10^{-14}	2×10^{-8}	3×10^{-14}	2×10^{-8}
	Cm 249	W	1×10^{-9}	1×10^{-4}	1×10^{-9}	1×10^{-5}
	Cm 250	W	1×10^{-13}	5×10^{-8}	1×10^{-13}	5×10^{-8}

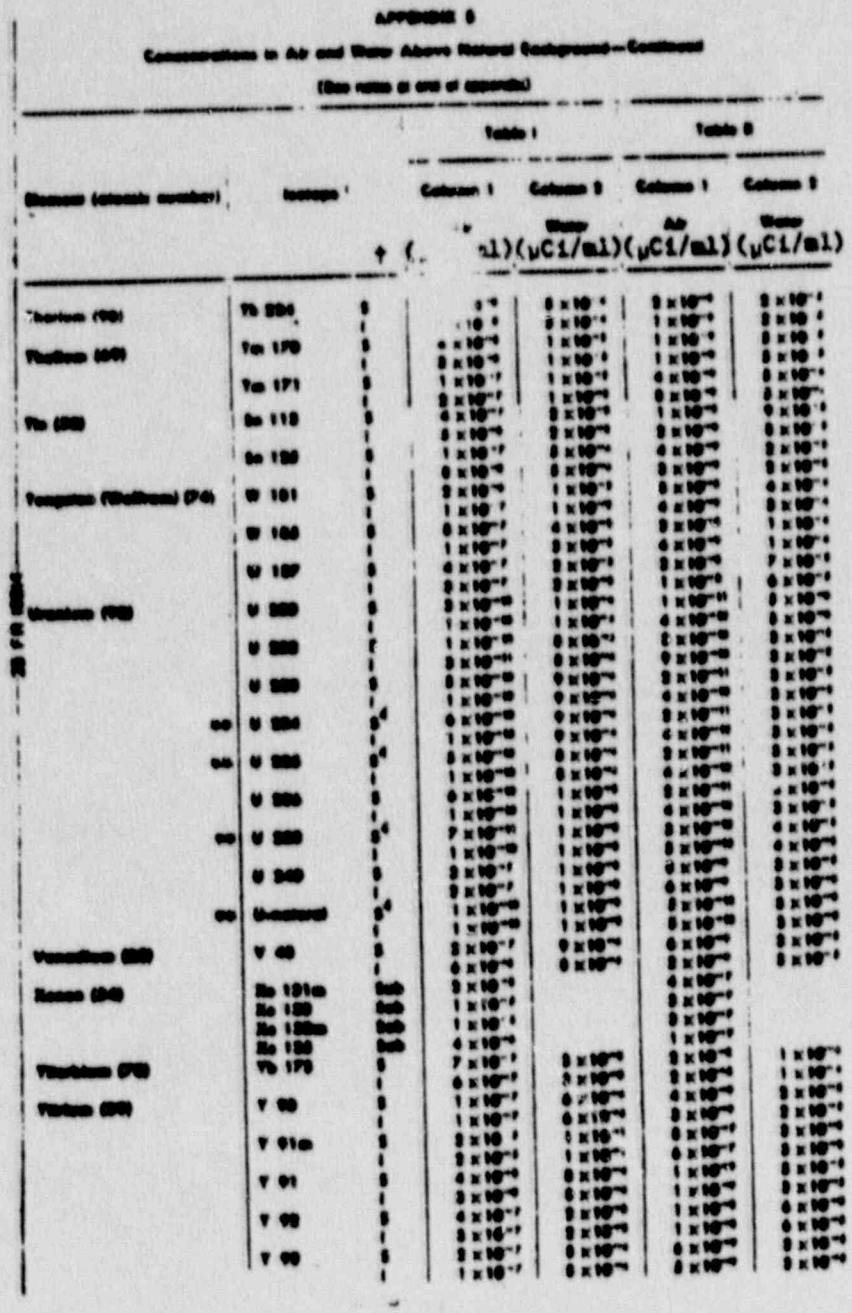
APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

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)
Molybdenum (42)	Mo 97	D	3 x 10⁻⁶	1 x 10⁻³	8 x 10⁻⁶	4 x 10⁻³
		W	2 x 10⁻⁶	1 x 10⁻³	6 x 10⁻⁶	3 x 10⁻³
	Mo 99	D	3 x 10⁻⁷	2 x 10⁻³	9 x 10⁻⁷	6 x 10⁻³
		W	2 x 10⁻⁶	2 x 10⁻³	5 x 10⁻⁶	6 x 10⁻³
	Mo 101	D	7 x 10⁻⁷	3 x 10⁻³	2 x 10⁻⁶	1 x 10⁻²
		W	3 x 10⁻⁶	3 x 10⁻³	9 x 10⁻⁶	1 x 10⁻²
Ruthenium (44)	Ru 103	D	6 x 10⁻⁷	4 x 10⁻³	2 x 10⁻⁶	1 x 10⁻²
		W	4 x 10⁻⁶	4 x 10⁻³	1 x 10⁻⁵	1 x 10⁻²
	Ru 105	D	4 x 10⁻⁷	3 x 10⁻³	1 x 10⁻⁶	1 x 10⁻²
		W	3 x 10⁻⁶	3 x 10⁻³	8 x 10⁻⁶	1 x 10⁻²
	Ru 106	D	2 x 10⁻⁸	2 x 10⁻⁴	6 x 10⁻⁸	6 x 10⁻⁴
		W	2 x 10⁻⁷	2 x 10⁻⁴	5 x 10⁻⁷	7 x 10⁻⁴
Antimony (51)	Sb 124	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	2 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Sb 125	D	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	4 x 10⁻³
	Sb 126	D	3 x 10⁻⁷	2 x 10⁻³	1 x 10⁻⁶	8 x 10⁻³
		W	2 x 10⁻⁶	2 x 10⁻³	6 x 10⁻⁶	8 x 10⁻³
Tellurium (52)	Te 125m	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	2 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Te 127m	D	6 x 10⁻⁸	3 x 10⁻⁴	2 x 10⁻⁷	1 x 10⁻³
		W	4 x 10⁻⁷	3 x 10⁻⁴	1 x 10⁻⁶	1 x 10⁻³
	Te 127	D	3 x 10⁻⁶	2 x 10⁻²	8 x 10⁻⁶	6 x 10⁻²
		W	2 x 10⁻⁵	2 x 10⁻²	6 x 10⁻⁵	6 x 10⁻²
	Te 129m	D	9 x 10⁻⁸	6 x 10⁻⁴	3 x 10⁻⁷	2 x 10⁻³
		W	6 x 10⁻⁷	6 x 10⁻⁴	2 x 10⁻⁶	2 x 10⁻³
	Te 131m	D	4 x 10⁻⁷	2 x 10⁻³	1 x 10⁻⁶	8 x 10⁻³
		W	3 x 10⁻⁶	2 x 10⁻³	8 x 10⁻⁶	8 x 10⁻³
	Te 132	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	4 x 10⁻³
Iodine (53)	I 130	D	2 x 10⁻⁸	1 x 10⁻⁴	6 x 10⁻⁸	4 x 10⁻⁴
		W	1 x 10⁻⁷	1 x 10⁻⁴	4 x 10⁻⁷	4 x 10⁻⁴
	I 131	D	1 x 10⁻⁸	6 x 10⁻⁵	3 x 10⁻⁸	2 x 10⁻⁴
		W	8 x 10⁻⁸	6 x 10⁻⁵	2 x 10⁻⁷	2 x 10⁻⁴
	I 132	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	4 x 10⁻³
	I 133	D	4 x 10⁻⁸	3 x 10⁻⁴	1 x 10⁻⁷	8 x 10⁻⁴
		W	3 x 10⁻⁷	3 x 10⁻⁴	1 x 10⁻⁶	8 x 10⁻⁴
	I 134	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	4 x 10⁻³
	I 135	D	6 x 10⁻⁸	4 x 10⁻⁴	2 x 10⁻⁷	1 x 10⁻³
		W	4 x 10⁻⁷	4 x 10⁻⁴	1 x 10⁻⁶	1 x 10⁻³
Xenon (54)	Xe 131m	D	4 x 10⁻⁶	3 x 10⁻²	1 x 10⁻⁵	8 x 10⁻²
		W	3 x 10⁻⁵	3 x 10⁻²	1 x 10⁻⁴	8 x 10⁻²
	Xe 133	D	1 x 10⁻⁶	1 x 10⁻²	4 x 10⁻⁶	3 x 10⁻²
		W	1 x 10⁻⁵	1 x 10⁻²	3 x 10⁻⁵	3 x 10⁻²
	Xe 135	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
Cesium (55)	Cs 134m	D	4 x 10⁻⁷	3 x 10⁻³	1 x 10⁻⁶	8 x 10⁻³
		W	3 x 10⁻⁶	3 x 10⁻³	8 x 10⁻⁶	8 x 10⁻³
	Cs 134	D	2 x 10⁻⁸	1 x 10⁻⁴	6 x 10⁻⁸	4 x 10⁻⁴
		W	1 x 10⁻⁷	1 x 10⁻⁴	4 x 10⁻⁷	4 x 10⁻⁴
	Cs 135	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Cs 136	D	6 x 10⁻⁸	4 x 10⁻⁴	2 x 10⁻⁷	1 x 10⁻³
		W	4 x 10⁻⁷	4 x 10⁻⁴	1 x 10⁻⁶	1 x 10⁻³
	Cs 137	D	3 x 10⁻⁸	2 x 10⁻⁴	1 x 10⁻⁷	6 x 10⁻⁴
		W	2 x 10⁻⁷	2 x 10⁻⁴	6 x 10⁻⁷	6 x 10⁻⁴
	Cs 138	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Barium (56)	Ba 131	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Ba 140	D	2 x 10⁻⁸	1 x 10⁻⁴	6 x 10⁻⁸	4 x 10⁻⁴
		W	1 x 10⁻⁷	1 x 10⁻⁴	4 x 10⁻⁷	4 x 10⁻⁴
Lanthanum (57)	La 140	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Cerium (58)	Ce 141	D	3 x 10⁻⁷	2 x 10⁻³	9 x 10⁻⁷	6 x 10⁻³
		W	2 x 10⁻⁶	2 x 10⁻³	6 x 10⁻⁶	6 x 10⁻³
	Ce 143	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
	Ce 144	D	1 x 10⁻⁸	6 x 10⁻⁵	3 x 10⁻⁸	2 x 10⁻⁴
		W	8 x 10⁻⁸	6 x 10⁻⁵	2 x 10⁻⁷	2 x 10⁻⁴
Praseodymium (59)	Pr 142	D	1 x 10⁻⁷	1 x 10⁻⁴	4 x 10⁻⁷	3 x 10⁻⁴
		W	1 x 10⁻⁷	1 x 10⁻⁴	3 x 10⁻⁷	3 x 10⁻⁴
	Pr 143	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
Neodymium (60)	Nd 147	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Nd 149	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Promethium (61)	Pm 147	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Pm 149	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Samarium (62)	Sm 151	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Sm 153	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Europium (63)	Eu 152	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Eu 154	D	1 x 10⁻⁸	6 x 10⁻⁵	3 x 10⁻⁸	2 x 10⁻⁴
		W	8 x 10⁻⁸	6 x 10⁻⁵	2 x 10⁻⁷	2 x 10⁻⁴
	Eu 155	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Gadolinium (64)	Gd 153	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Gd 159	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Terbium (65)	Tb 160	D	1 x 10⁻⁸	6 x 10⁻⁵	3 x 10⁻⁸	2 x 10⁻⁴
		W	8 x 10⁻⁸	6 x 10⁻⁵	2 x 10⁻⁷	2 x 10⁻⁴
Dysprosium (66)	Dy 165	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
	Dy 166	D	1 x 10⁻⁸	6 x 10⁻⁵	3 x 10⁻⁸	2 x 10⁻⁴
		W	8 x 10⁻⁸	6 x 10⁻⁵	2 x 10⁻⁷	2 x 10⁻⁴
Holmium (67)	Ho 166	D	1 x 10⁻⁸	6 x 10⁻⁵	3 x 10⁻⁸	2 x 10⁻⁴
		W	8 x 10⁻⁸	6 x 10⁻⁵	2 x 10⁻⁷	2 x 10⁻⁴
Erbium (68)	Er 169	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Er 171	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Thulium (69)	Tm 170	D	1 x 10⁻⁸	6 x 10⁻⁵	3 x 10⁻⁸	2 x 10⁻⁴
		W	8 x 10⁻⁸	6 x 10⁻⁵	2 x 10⁻⁷	2 x 10⁻⁴
	Tm 171	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Ytterbium (70)	Yb 175	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Lutetium (71)	Lu 177	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Hafnium (72)	Hf 181	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
Tungsten (74)	W 187	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
Rhenium (75)	Re 183	D	3 x 10⁻⁷	2 x 10⁻³	9 x 10⁻⁷	6 x 10⁻³
		W	2 x 10⁻⁶	2 x 10⁻³	6 x 10⁻⁶	6 x 10⁻³
	Re 186	D	9 x 10⁻⁸	6 x 10⁻⁴	3 x 10⁻⁷	2 x 10⁻³
		W	6 x 10⁻⁷	6 x 10⁻⁴	2 x 10⁻⁶	2 x 10⁻³
	Re 187	D	2 x 10⁻⁶	1 x 10⁻²	6 x 10⁻⁶	4 x 10⁻²
		W	1 x 10⁻⁵	1 x 10⁻²	4 x 10⁻⁵	4 x 10⁻²
	Re 188	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Osmium (76)	Os 185	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
	Os 191m	D	3 x 10⁻⁶	2 x 10⁻²	9 x 10⁻⁶	6 x 10⁻²
		W	2 x 10⁻⁵	2 x 10⁻²	6 x 10⁻⁵	6 x 10⁻²
	Os 191	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Os 193	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Iridium (77)	Ir 190	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Ir 192	D	2 x 10⁻⁸	1 x 10⁻⁴	6 x 10⁻⁸	4 x 10⁻⁴
		W	1 x 10⁻⁷	1 x 10⁻⁴	4 x 10⁻⁷	4 x 10⁻⁴
	Ir 194	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Platinum (78)	Pt 191	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Pt 193m	D	1 x 10⁻⁶	1 x 10⁻²	4 x 10⁻⁶	3 x 10⁻²
		W	1 x 10⁻⁵	1 x 10⁻²	3 x 10⁻⁵	3 x 10⁻²
	Pt 193	D	1 x 10⁻⁶	1 x 10⁻²	4 x 10⁻⁶	3 x 10⁻²
		W	1 x 10⁻⁵	1 x 10⁻²	3 x 10⁻⁵	3 x 10⁻²
	Pt 197m	D	1 x 10⁻⁶	1 x 10⁻²	4 x 10⁻⁶	3 x 10⁻²
		W	1 x 10⁻⁵	1 x 10⁻²	3 x 10⁻⁵	3 x 10⁻²
	Pt 197	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
Gold (79)	Au 198	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Au 199	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Mercury (80)	Hg 197m	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Hg 197	D	3 x 10⁻⁷	2 x 10⁻³	9 x 10⁻⁷	6 x 10⁻³
		W	2 x 10⁻⁶	2 x 10⁻³	6 x 10⁻⁶	6 x 10⁻³
	Hg 203	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Thallium (81)	Tl 200	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
	Tl 201	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
	Tl 202	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
	Tl 204	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Lead (82)	Pb 203	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
Bismuth (83)	Bi 205	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Bi 206	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³
Polonium (84)	Po 203	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Po 205	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Po 207	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
Astatine (85)	At 211	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
Radon (86)	Rn 220	D	3 x 10⁻⁶	2 x 10⁻²	9 x 10⁻⁶	6 x 10⁻²
		W	2 x 10⁻⁵	2 x 10⁻²	6 x 10⁻⁵	6 x 10⁻²
	Rn 222	D	2 x 10⁻⁶	1 x 10⁻²	6 x 10⁻⁶	4 x 10⁻²
		W	1 x 10⁻⁵	1 x 10⁻²	4 x 10⁻⁵	4 x 10⁻²
Francium (87)	Fr 222	D	2 x 10⁻⁷	1 x 10⁻³	6 x 10⁻⁷	4 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	4 x 10⁻⁶	4 x 10⁻³
	Fr 223	D	1 x 10⁻⁷	1 x 10⁻³	4 x 10⁻⁷	3 x 10⁻³
		W	1 x 10⁻⁶	1 x 10⁻³	3 x 10⁻⁶	3 x 10⁻³

[illegible]

Element (atomic number)	Isotope		Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
[illegible]	Tc 96m	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	Tc 96	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	Tc 97m	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	Tc 97	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	Tc 99m	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	Tc 99	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Te 125m	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	Te 127m	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	Te 127	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	Te 129m	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	Te 129	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	Te 131m	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	Te 132	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Tb 160	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] (81)	Tl 200	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	Tl 201	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	Tl 202	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	Tl 204	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	• Th 227	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	Th 228	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	Th 230	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	• Th 231	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	Th 232	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]
	•[illegible] Th natural	S	[illegible]	[illegible]	[illegible]	[illegible]
		I	[illegible]	[illegible]	[illegible]	[illegible]



Appendix B

Concentrations in Air and Water Above Natural Background—Continued

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)
[illegible]	[illegible]	0	1 x 10⁻¹¹	0 x 10⁻⁶	4 x 10⁻⁶	1 x 10⁻⁴
		1	6 x 10⁻¹⁰	0 x 10⁻⁶	0 x 10⁻⁶	0 x 10⁻⁴
	[illegible]	0	4 x 10⁻¹¹	0 x 10⁻⁶	1 x 10⁻⁶	7 x 10⁻⁴
		1	3 x 10⁻¹⁰	0 x 10⁻⁶	1 x 10⁻⁶	0 x 10⁻⁴
	[illegible]	0	7 x 10⁻¹¹	0 x 10⁻⁶	3 x 10⁻⁷	3 x 10⁻⁴
		1	9 x 10⁻¹⁰	0 x 10⁻⁶	3 x 10⁻⁷	3 x 10⁻⁴
[illegible] (40)	[illegible]	0	1 x 10⁻¹¹	0 x 10⁻⁶	4 x 10⁻⁶	0 x 10⁻⁴
		1	9 x 10⁻¹¹	0 x 10⁻⁶	1 x 10⁻⁶	0 x 10⁻⁴
	[illegible]	0	1 x 10⁻¹¹	0 x 10⁻⁶	4 x 10⁻⁷	4 x 10⁻⁴
		1	3 x 10⁻¹⁰	0 x 10⁻⁶	1 x 10⁻⁶	0 x 10⁻⁴
	[illegible]	0	1 x 10⁻¹¹	0 x 10⁻⁶	4 x 10⁻⁷	3 x 10⁻⁴
		1	9 x 10⁻¹⁰	0 x 10⁻⁶	3 x 10⁻⁷	3 x 10⁻⁴
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours.		Sub	1 x 10⁻⁶		3 x 10⁻⁷	
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours.			3 x 10⁻⁸	9 x 10⁻⁷	1 x 10⁻⁸	3 x 10⁻⁶
Any single radionuclide not listed above, which decays by alpha emission or spontaneous fission.			6 x 10⁻¹⁰	6 x 10⁻⁷	2 x 10⁻¹¹	3 x 10⁻⁹

[illegible] Isotopes.

"Sub" means less than one but greater than zero.

[illegible]

[illegible]

[illegible]

*Amended 37 F.R. 23319.

**Amended 39 F.R. 23990; formerly redesignated 40 F.R. 59704.

***Amended 40 F.R. 59704.

†Amended 36 F.R. 20315.

‡Amended 39 F.R. 23990; redesignated 40 F.R. 59704.

NOTE TO APPENDIX B

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 by 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—6×10^{-14} µCi/ml.
b. For purposes of Table I, Col. 2—4×10^{-7} µCi/ml.
c. For purposes of Table II, Col. 1—9×10^{-8} µCi/ml.
d. For purposes of Table II, Col. 2—3×10^{-4} µCi/ml.

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

a. If the identity of each radionuclide in the mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the concentration limit for the mixture is the limit specified in Appendix B for the radionuclide in the mixture having the lowest concentration limit; or

b. If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in Appendix B are not present in the mixture, the concentration limit for the mixture is the lowest concentration limit specified in Appendix B for any radionuclide which is not known to be absent from the mixture; or

A. Element (atomic number) and 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)
Antimony (51): Sb-122, Sb-124, Sb-125		2×10^{-3}		9×10^{-3}
Arsenic (33): As-73, As-74, As-76, As-77		5×10^{-3}		2×10^{-2}
Barium (56): Ba-131, Ba-140		3×10^{-3}		1×10^{-2}
Beryllium (4): Be-7		2×10^{-2}		1×10^{-1}
Cadmium (48): Cd-109, Cd-115m, Cd-115	3×10^{-12}		1×10^{-10}	
Calcium (20): Ca-45	3×10^{-12}		1×10^{-10}	
Carbon (6): C-14	3×10^{-12}		1×10^{-10}	
Cerium (58): Ce-141, Ce-143, Ce-144	3×10^{-12}		1×10^{-10}	

4. If a mixture of radionuclides consists of uranium and its daughters in ore dust prior to chemical separation of the uranium from the ore, the values specified below may be used for uranium and its daughters through radium-226, instead of those from paragraphs 1, 2, or 3 above.

a. For purposes of Table I, Col. 1—1×10^{-12} µCi/ml gross alpha activity or 5×10^{-6} µCi/ml natural uranium or 10 milligrams per cubic meter of air natural uranium.

b. For purposes of Table II, Col. 1—3×10^{-11} µCi/ml gross alpha activity or 1×10^{-4} µCi/ml natural uranium or 1 milligram per cubic meter of air natural uranium.

5. For purposes of this note, a radionuclide may be considered as not present in a mixture if (a) the ratio of the concentration of that radionuclide in the mixture (C_A) to the concentration limit for that radionuclide specified in Table II of Appendix B (EPC_A) does not exceed $\frac{1}{10}$ (i.e., $\frac{C_A}{EPC_A} \leq \frac{1}{10}$) and (b) the sum of such ratios for all the radionuclides considered as not present in the mixture does not exceed $\frac{1}{4}$ (i.e., $\frac{C_A}{EPC_A} + \frac{C_B}{EPC_B} + \cdots \leq \frac{1}{4}$).

Appendix C

Material	Microcuries
Americium-241	01
Antimony-122	100
Antimony-124	10
Antimony-125	10
Arsenic-73	100
Arsenic-74	10
Arsenic-76	10
Arsenic-77	100
Barium-131	10
Barium-133	10
Barium-133m	10
Barium-140	10
Bismuth-210	1
Bromine-82	10
Cadmium-109	10
Cadmium-115m	10
Cadmium-115	100
Calcium-45	10
Calcium-47	10
Carbon-14	100
Cerium-141	100
Cerium-143	100
Cerium-144	1
Cesium-131	1,000
Cesium-134m	100
Cesium-134	1
Cesium-135	10
Cesium-136	10
Cesium-137	10
Chlorine-36	10
Chlorine-38	10
Chromium-51	1,000
Cobalt-57	10
Cobalt-58	10
Cobalt-60	1
Copper-64	100
Dysprosium-165	10
Dysprosium-166	100
Erbium-169	100
Erbium-171	100
Europium-152 9.2 h	100
Europium-152 13.33 y	1
Europium-154	1
Europium-155	10
Fluorine-18	1,000
Gadolinium-153	10
Gadolinium-159	100
Gallium-72	10
Germanium-71	100
Gold-198	100
Gold-199	100
Hafnium-181	10
Holmium-166	100
Hydrogen-3	1,000
Indium-113m	100
Indium-114m	10
Indium-115m	100
Indium-115	10
Iodine-125	1
Iodine-126	1
Iodine-129	0.1
Iodine-131	1
Iodine-132	10
Iodine-133	1
Iodine-134	10
Iodine-135	10
Iridium-192	10
Iridium-194	100
Iron-55	100
Iron-59	10
Krypton-85	100
Krypton-87	10
Lanthanum-140	10
Lutetium-177	100
Manganese-52	10
Manganese-54	10
Manganese-56	10
Mercury-197m	100
Mercury-197	100
Mercury-203	10
Molybdenum-99	100
Neodymium-147	100
Neodymium-149	100
Nickel-59	100
Nickel-63	10
Nickel-65	100
Niobium-93m	10
Niobium-95	10
Niobium-97	10
Osmium-185	10

Material	Microcuries
Osmium-191m[1]	100
Osmium-191	100
Osmium-193	100
Palladium-103	100
Palladium-109	100
Phosphorus-32	10
Platinum-191	100
Platinum-193m	100
Platinum-193	100
Platinum-197m	100
Platinum-197	100
Plutonium-238	0.1
Plutonium-239	0.1
Polonium-210	10
Potassium-42	10
Praseodymium-142	100
Praseodymium-143	100
Promethium-147	10
Promethium-149	10
Radium-226	0.1
Rhenium-186	100
Rhenium-188	100
Rhodium-103m	100
Rhodium-105	100
Rubidium-86	10
Rubidium-87	10
Ruthenium-97	100
Ruthenium-103	10
Ruthenium-105	10
Ruthenium-106	1
Samarium-145	100
Samarium-147	100
Samarium-151	10
Samarium-153	100
Scandium-46	10
Scandium-47	100
Scandium-48	10
Selenium-75	10
Silicon-31	100
Silver-105	10
Silver-110m	1
Silver-111	100
Sodium-24	10
Strontium-85	10
Strontium-89	1
Strontium-90	0.1
Strontium-91	10
Strontium-92	10
Sulphur-35	100
Tantalum-182	10
Technetium-96	10
Technetium-96m	1000
Technetium-97	100
Technetium-97m	100
Technetium-99	10
Tellurium-125m	10
Tellurium-127m	10
Tellurium-127	100
Tellurium-129m	10
Tellurium-129	100
Tellurium-131m	10
Tellurium-132	10
Terbium-160	10
Thallium-200	100
Thallium-201	100
Thallium-202	100
Thallium-204	10
Thorium (natural)[2]	100
Thulium-170	10
Thulium-191	10
Tin-113	10
Tin-125	10
Tungsten-181	10
Tungsten-185	10
Tungsten-187	100
Uranium (natural)[3]	100
Uranium-233	0.1
Uranium-234, Uranium-235	0.1
Vanadium-48	10
Xenon-131m	1,000
Xenon-133	100
Xenon-135	100
Ytterbium-175	100
Yttrium-90	10
Yttrium-91	10
Yttrium-92	100
Yttrium-93	100
Zinc-65	10
Zinc-69m	100
Zinc-69	1,000
Zirconium-93	10
Zirconium-95	10
Zirconium-97	10

Any single radioisotope not listed above or mixture of alpha emitters of unknown composition 0.1

Any radioisotope other than alpha emitting radioisotopes not listed above or mixture of beta emitters of unknown composition 1

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

[1] Based on alpha disintegration rate of Th-232, Th-228 and their daughter products.

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

* Amended 36 FR 16900.

** Amended 39 FR 23990.

APPENDIX D.—UNITED STATES NUCLEAR REGULATORY COMMISSION REGIONAL OFFICES

	Address	Telephone (24 hours)
Region I: Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.	USNRC, 631 Park Avenue, King of Prussia, PA 19406.	(215) 337-5000 (FTS) 596-1000
Region II: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, Puerto Rico, South Carolina, Tennessee, Virginia, Virgin Islands, and West Virginia.	USNRC, 101 Marietta Street, NW., Suite 2900, Atlanta, GA 30323.	(404) 331-4503 (FTS) 242-4503
Region III: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin.	USNRC, 799 Roosevelt Road, Glen Ellyn, IL 60137.	(312) 790-5500 (FTS) 530-5500
Region IV: Arkansas, Colorado, Idaho, Kansas, Louisiana, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, and Wyoming.	USNRC, 611 Ryan Plaza Drive, Suite 1000, Arlington, TX 76011.	(817) 860-8100 (FTS) 736-8100
Region IV: Navy Ships	USNRC, Region IV Liaison Resident Field Office, 700 Shoreline Drive, P.O. Box 29866, Seattle, WA 98104.	(206) 442-5600 (FTS) 399-5600
Region V: Alaska, Arizona, California, Hawaii, Nevada, Oregon, Pacific Trust Territories, and Washington.	USNRC, 1450 Maria Lane, Suite 210, Walnut Creek, CA 94596.	(415) 943-3700 (FTS) 463-3700

PART 34

LICENSES FOR RADIOGRAPHY AND RADIATION SAFETY REQUIREMENTS FOR RADIOGRAPHIC OPERATIONS

Sec.

51 FR 21736

Authority: Secs. 81, 161, 182, 183, 68 Stat. 935, 948, 953, 954, as amended (42 U.S.C. 2111, 2201, 2232, 2233); sec. 201, 88 Stat. 1242, as amended (42 U.S.C. 5841).

Section 34.32 also issued under sec. 206, 88 Stat. 1246 (42 U.S.C. 5846).

For the purposes of sec. 223, 68 Stat. 958, as amended (42 U.S.C. 2273): §§ 34.22, 34.23, 34.24, 34.25 (a), (b), and (d), 34.26, 34.29, 34.31 (a) and (b), 34.32, 34.33 (a), (c), and (d), 34.41, 34.42, 34.43(a), (b), and (c), and 34.44 are issued under sec. 161b, 68 Stat. 948, as amended (42 U.S.C. 2201(b)); and §§ 34.11(d), 34.25 (c) and (d), 34.26, 34.27, 34.28(b), 34.28(c), 34.31(c), 34.33 (b) and (e), and 34.43(d) are issued under sec. 161o, 68 Stat. 950, as amended (42 U.S.C. 2201(o)). §§ 34.2, 34.11, 34.22, 34.28, 34.29, 34.31, 34.32, 34.33, 34.43, 34.44, 34.51, and Appendix A—[Amended]

§ 34.1 Purpose and scope.

This part prescribes requirements for the issuance of licenses for the use of sealed sources containing byproduct material and radiation safety requirements for persons using such sealed sources in radiography. The provisions and requirements of this part are in addition to, and not in substitution for, other requirements of this chapter. In particular, the provisions of Part 30 of this chapter apply to applications and licenses subject to this part. Nothing in this part shall apply to uses of byproduct material for medical diagnosis or therapy.

50 FR 9105

§ 34.2 Definitions.

As used in this part:

"Permanent radiographic installation" means a shielded installation or structure designed or intended for radiography and in which radiography is regularly performed.

"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 ensuring compliance with the requirements of the Commission's regulations and the conditions of the license;

"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 radiation survey instruments in radiography;

"Radiographic exposure device" means any instrument containing a sealed source fastened or contained therein, in which the sealed source or shielding thereof may be moved, or otherwise changed, from a shielded to unshielded position for purposes of making a radiographic exposure;

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

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

"Storage area" means any location, facility, or vehicle which is used to store, to transport, or to secure a radiographic exposure device, a storage container, or a sealed source when it is not in use and which is locked or has a physical barrier to prevent accidental exposure, tampering with, or unauthorized removal of the device, container, or source.

"Storage container" means a device in which sealed sources are transported or stored.

"Source changer" means a device designed and used for replacement of sealed sources in radiographic exposure devices, including those also used for transporting and storage of sealed sources.

51 FR 21736

49 FR 27053

§ 34.3 Applications for specific licenses.

A person may file an application for specific license for use of sealed sources in radiography in duplicate on NRC Form 313, "Application for Material License," in accordance with the provisions of § 30.32 of this chapter.

49 FR 19629

§ 34.8 Information collection requirements: OMB approval.

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). OMB has approved the information collection requirements contained in this part under control number 3150-0007.

(b) The approved information collection requirements contained in this part appear in §§ 34.11, 34.24, 34.25, 34.26, 34.27, 34.28, 34.29, 34.31, 34.32, 34.36, and 34.43.

(c) This part contains information collection requirements in addition to those approved under the control number specified in paragraph (a) of this section. These information collection requirements and the control numbers under which they are approved are as follows:

(1) In § 34.3, Form NRC-313R is approved under control number 3150-0120.

Subpart A—Specific Licensing Requirements

§ 34.11 Issuance of specific licenses for use of sealed sources in radiography.

An application for a specific license for use of sealed sources in radiography will be approved if:

(a) The applicant satisfies the general requirements specified in § 30.33 of this chapter;

(b) The applicant will have an adequate program for training radiographers and radiographers' assistants and submits to the Commission a schedule or description of such program which specifies the:

(1) Initial training;

(2) Periodic training;

(3) On-the-job training;

(4) Means to be used by the licensee to determine the radiographer's knowledge and understanding of and ability to comply with Commission regulations and licensing requirements, and the operating and emergency procedures of the applicant; and

(5) Means to be used by the licensee to determine the radiographer's assistant's knowledge and understanding of and ability to comply with the operating and emergency procedures of the applicant;

(c) The applicant has established and submits to the Commission satisfactory written operating and emergency procedures as described in § 34.32;

(d) The applicant has established and submits to the Commission a description of its inspection program adequate to ensure that its radiographers and radiographers' assistants follow the Commission's regulatory requirements and the applicant's operating and emergency procedures. The inspection program must:

(1) Include observation of the performance of each radiographer and radiographer's assistant during an actual radiographic operation at intervals not to exceed three months;

(2) Provide that, if a radiographer or a radiographer's assistant has not participated in a radiographic operation for more than three months since the last inspection, that individual's performance must be observed and recorded the next time the individual participates in a radiographic operation; and

(3) Include the retention of inspection records on the performance of radiographers or radiographers' assistants for three years.

(e) The applicant submits a description of its overall organizational structure pertaining to the radiography program, including specified delegations of authority and responsibility for operation of the program; and

(f) The applicant who desires to conduct his own leak tests has established adequate procedures to be followed in leak testing sealed sources, for possible leakage and contamination and submits to the Commission a description of such procedures including:

(1) Instrumentation to be used,

(2) Method of performing test, e.g., points on equipment to be smeared and method of taking smear, and

(3) Pertinent experience of the person who will perform the test.

Subpart B—Radiation Safety Requirements

EQUIPMENT CONTROL

§ 34.31 Limits on levels of radiation for radiographic exposure devices and storage containers.

Radiographic exposure devices measuring less than four (4) inches from the sealed source storage position to any exterior surface of the device shall have no radiation level in excess of 50 milliroentgens per hour at six (6) inches from any exterior surface of the device. Radiographic exposure devices measuring a minimum of four (4) inches from the sealed source storage position to any exterior surface of the device, and all storage containers for sealed sources or for radiographic exposure devices, shall have no radiation level in excess of 200 milliroentgens per hour at any exterior surface, and ten (10) milliroentgens per hour at one meter from any exterior surface. The radiation levels specified are with the sealed source in the shielded (i.e., "off") position.

§ 34.33 Locking of radiographic exposure devices, storage containers, and source changers.

(a) Each radiographic exposure device shall have a lock or outer locked container designed to prevent unauthorized or accidental removal of the sealed source from its shielded position. The exposure device or its container shall be kept locked when not under the direct surveillance of a radiographer or a radiographer's assistant or as otherwise may be authorized in § 34.61. In addition, during radiographic operations the sealed source assembly shall be secured in the shielded position each time the source is returned to that position.

(b) Each sealed source storage container and source changer shall have a lock or outer locked container designed to prevent unauthorized or accidental removal of the sealed source from its shielded position. Storage containers and source changers shall be kept locked when containing sealed sources except when under the direct surveillance of a radiographer or a radiographer's assistant.

§ 34.23 Storage precautions.

Locked radiographic exposure devices and storage containers shall be physically secured to prevent tampering or removal by unauthorized personnel.

§ 34.24 Radiation survey instruments.

The licensee shall maintain sufficient calibrated and operable radiation survey instruments to make physical radiation surveys as required by this part and Part 20 of this chapter.

Each radiation survey instrument shall be calibrated at intervals not to exceed three months and after each instrument servicing and a record shall be maintained of the results of each instrument calibration and date thereof for two years after the date of calibration.

Instrumentation required by this section shall have a range such that two millirocntgens per hour through one roentgen per hour can be measured

§ 34.25 Leak testing, repair, tagging, opening, modification and replacement of sealed sources.

(a) The replacement of any sealed source fastened to or contained in a radiographic exposure device and leak testing, repair, tagging, opening or any other modification of any sealed source shall be performed only by persons specifically authorized by the Commission to do so.

(b) Each sealed source shall be tested for leakage at intervals not to exceed 6 months. In the absence of a certificate from a transferor that a test has been made within the 6 months prior to the transfer, the sealed source shall not be put into use until tested.

(c) The leak test shall be capable of detecting the presence of 0.005 microcurie of removable contamination on the sealed source. An acceptable leak test for sealed sources in the possession of a radiography licensee would be to test at the nearest accessible point to the sealed source storage position, or other appropriate measuring point, by a procedure to be approved pursuant to §34.11(f).

Records of leak test results shall be kept in units of microcuries and maintained for inspection by the Commission for six months after the next required leak test is performed or until the sealed source is transferred or disposed of.

(d) Any test conducted pursuant to paragraphs (b) and (c) of this section which reveals the presence of 0.005 microcurie or more of removable radioactive material shall be considered evidence that the sealed source is leaking. The licensee shall immediately withdraw the equipment involved from use and shall cause it to be decontaminated and repaired or to be disposed of, in accordance with Commission regulations. A report shall be filed, within 5 days of the test, with the Director of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, describing the equipment involved, the test results, and the corrective action taken. A copy of such report shall be sent to the Director of the appropriate Nuclear Regulatory Commission's Inspection and Enforcement Regional Office listed in Appendix D of Part 20 of this chapter "Standards for Protection Against Radiation."

(e) A sealed source which is not fastened to or contained in a radiographic exposure device shall have permanently attached to it a durable tag at least one (1) inch square bearing the prescribed radiation caution symbol in conventional colors, magenta or purple on a yellow background, and at least the instructions: "Danger – Radioactive Material – Do Not Handle – Notify Civil Authorities if Found."

§ 34.26 Quarterly inventory.

Each licensee shall conduct a quarterly physical inventory to account for all sealed sources received and possessed under his license. The records of the inventories shall be maintained for two years from the date of the inventory for inspection by the Commission, and shall include the quantities and kinds of byproduct material, location of sealed sources, and the date of the inventory.

§ 34.27 Utilization logs.

Each licensee shall maintain current logs, which shall be kept available for two years from the date of the recorded event, for inspection by the Commission, at the address specified in the license, showing for each sealed source the following information:

(a) A description (or make and model number) of the radiographic exposure device or storage container in which the sealed source is located;

(b) The identity of the radiographer to whom assigned; and

(c) The plant or site where used and dates of use.

§ 34.28 Inspection and maintenance of radiographic exposure devices, storage containers, and source changers.

(a) The licensee shall check for obvious defects in radiographic exposure devices, storage containers, and source changers prior to use each day the equipment is used.

(b) The licensee shall conduct a program for inspection and maintenance of radiographic exposure devices, storage containers, and source changers at intervals not to exceed three months or prior to the first use thereafter to assure proper functioning of components important to safety. Records of these inspections and maintenance shall be kept for two years.

§ 34.29 Permanent radiographic installations.

(a) Permanent radiographic installations having high radiation area entrance controls of the types described in § 20.203(c) (2)(ii), (2)(iii), or (4) shall also meet the following special requirement.

(b) Each entrance that is used for personnel access to the high radiation area in a permanent radiographic installation to which this section applies shall have both visible and audible warning signals to warn of the presence of radiation. The visible signal shall be actuated by radiation whenever the source is exposed. The audible signal shall be actuated when an attempt is made to enter the installation while the source is exposed.

(c) The alarm system shall be tested at intervals not to exceed three months or prior to the first use thereafter of the source in the installation. Records of the tests shall be kept for two years.

PERSONAL RADIATION SAFETY REQUIREMENTS FOR RADIOGRAPHERS AND RADIOGRAPHERS' ASSISTANTS

§ 34.31 Training.

(a) The licensee shall not permit any individual to act as a radiographer until such individual:

(1) Has been instructed in the subjects outlined in Appendix A of this part;

(2) Has received copies of and instruction in NRC regulations contained in this part and in the applicable sections of Parts 19 and 20 of this chapter, NRC license(s) under which the radiographer will perform radiography, and the licensee's operating and emergency procedures;

(3) Has demonstrated competence to use the licensee's radiographic exposure devices, sealed sources, related handling tools, and survey instruments; and

(4) Has demonstrated understanding of the instructions in this paragraph (a) by successful completion of a written test and a field examination on the subjects covered.

(b) The licensee shall not permit any individual to act as a radiographer's assistant until such individual:

(1) Has received copies of and instruction in the licensee's operating and emergency procedures;

(2) Has demonstrated competence to use, under the personal supervision of the radiographer, the radiographic exposure devices, sealed sources, related handling tools, and radiation survey instruments that the assistant will use; and

(3) Has demonstrated understanding of the instructions in this paragraph (b) by successfully completing a written or oral test and a field examination on the subjects covered.

(c) Records of the above training, including copies of written tests and dates of oral tests and field examinations, shall be maintained for three years.

§ 34.31 Operating and emergency procedures.

The licensee's operating and emergency procedures shall include instructions in at least the following:

(a) The handling and use of licensed sealed sources and radiographic exposure devices to be employed such that no person is likely to be exposed to radiation doses in excess of the limits established in Part 20 of this chapter "Standards for Protection Against Radiation";

(b) Methods and occasions for conducting radiation surveys;

(c) Methods for controlling access to radiographic areas;

(d) Methods and occasions for locking and securing radiographic exposure devices, storage containers and sealed sources;

(e) Personnel monitoring and the use of personnel monitoring equipment;

(f) Transporting sealed sources to field locations, including posting of radiographic exposure devices and storage containers in the vehicles, posting of vehicles and control of the sealed sources during transportation;

(g) Minimizing exposure of persons in the event of an accident;

(h) The procedure for notifying proper persons in the event of an accident; and

(i) Maintenance of records.

(j) The inspection and maintenance of radiographic exposure devices and storage containers.

(k) Steps that must be taken immediately by radiography personnel in the event a pocket dosimeter is found to be off-scale.

(l) The procedure(s) for identifying and reporting defects and noncompliance, as required by Part 21 of this chapter.

§ 34.33 Personnel monitoring.

(a) The licensee shall not permit any individual to act as a radiographer or a radiographer's assistant unless, at all times during radiographic operations, each such individual wears a direct reading pocket dosimeter and either a film badge or a thermoluminescent dosimeter (TLD). Pocket dosimeters shall have a range from zero to at least 200 milliroentgens and shall be recharged at the start of each shift. Each film badge and TLD shall be assigned to and worn by only one individual.

(b) Pocket dosimeters shall be read and exposures recorded daily.

(c) Pocket dosimeters shall be checked at periods not to exceed one year for correct response to radiation. Acceptable dosimeters shall read within plus or minus 30 percent of the true radiation exposure.

(d) If an individual's pocket dosimeter is discharged beyond its range, his film badge or TLD shall be immediately sent for processing.

(e) Reports received from the film badge or TLD processor shall be kept for inspection until the Commission authorizes their disposal. Records of daily pocket dosimeter readings shall be kept for two years.

Radiographic Precautions and Radiographic Operations

§ 34.41 Security.

During each radiographic operation the radiographer or radiographer's assistant shall maintain a direct surveillance of the operation to protect against unauthorized entry into a high radiation area, as defined in Part 20 of this chapter, except (a) where the high radiation area is equipped with a control device or an alarm system as described in § 20.203(c)(3) of this chapter, or (b) where the high radiation area is locked to protect against unauthorized or accidental entry.

§ 34.42 Posting.

Notwithstanding any provisions in § 20.203(c) of this chapter, areas in which radiography is being performed shall be conspicuously posted as required by § 20.203(b) and (c)(1) of this chapter.

§ 34.43 Radiation surveys.

The licensee shall ensure that:

(a) At least one calibrated and operable radiation survey instrument is available at the location of its radiographic operations whenever radiographic operations are being performed, and at the storage area, as defined in § 34.2, whenever a radiographic exposure device, a storage container, or source is being placed in storage.

(b) A survey with a calibrated and operable radiation survey instrument is made after each exposure to determine that the sealed source has been returned to its shielded position. The entire circumference of the radiographic exposure device must be surveyed. If the radiographic exposure device has a source guide tube, the survey must include the guide tube.

(c) A survey with a calibrated and operable radiation survey instrument is made at any time a radiographic exposure device is placed in a storage area, as defined in § 34.2, to determine that the sealed source is in its shielded position. The entire circumference of the radiographic exposure device must be surveyed.

(d) A record of the storage survey required in paragraph (c) is made and is retained for three years when that storage survey is the last one performed in the work day.

§ 34.44 Supervision of radiographers' assistants.

Whenever a radiographer's assistant uses radiographic exposure devices, uses sealed sources or related source handling tools, or conducts radiation surveys required by § 34.43(b) to determine that the sealed source has returned to the shielded position after an exposure, he shall be under the personal supervision of a radiographer. The personal supervision shall include: (a) The radiographer's personal presence at the site where the sealed sources are being used, (b) the ability of the radiographer to give immediate assistance if required, and (c) the radiographer's watching the assistant's performance of the operations referred to in this section.

Exemptions

§ 34.51 Applications for exemptions.

The Commission may, upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

Appendix A

I. Precautions of Radiation Safety

A. Characteristics of gamma radiation.

B. Units of radiation dose (roentgen) and quantity of radioactivity (curie).

C. Hazards of exposure to radiation.

D. Levels of radiation from licensed material.

E. Methods of controlling radiation dose.

1. Working time.

2. Working distance.

3. Shielding.

II. Radiation Detection Instrumentation To Be Used

A. Use of radiation survey instruments.

1. Operation.

2. Calibration.

3. Limitations.

B. Survey technique.

C. Use of personnel monitoring equipment.

1. Film badges and thermoluminescent dosimeters (TLD's).

2. Pocket dosimeters.

III. Radiographic Equipment To Be Used

A. Remote handling equipment.

B. Radiographic exposure devices.

C. Storage containers.

IV. Inspections and Maintenance Performed by the Radiographers

V. Case Histories of Radiography Accidents

[Note removed 49 FR 19623]

SECTION III

TRAINING PROGRAM

SECTION III.A

TRAINING PROCEDURE

SECTION III.A

RADIOGRAPHIC TRAINING PROCEDURES

A. PURPOSE

This training procedure establishes Law Engineering's program for training and examining individuals who are radiographic technician candidates.

B. SCOPE

This procedure shall apply to all individuals who receive, possess, use or transfer any source of radiation within an Agreement State or within the jurisdiction of the Nuclear Regulatory Commission under Law Engineering's license. In addition, it will apply to all such individuals who operate x-ray equipment.

C. LEVELS OF QUALIFICATION

There shall be three levels of qualification under Law Engineering's Radiation Safety License. The duties and responsibilities of each of these levels are detailed in the Administrative Control and Radiation Protection Procedure section of this Safety Manual.

1. Radiation Safety Officer

All Radiation Safety Officers will have satisfactorily completed a minimum of a one-week (40 hour) program in radiation safety. This program may be administered by either Law Engineering personnel or by commercial consultants. The Radiation Safety Officer should also have a minimum of one year of actual experience as a radiographer.

2. Radiographer

All candidates for the position of Radiographer shall have satisfactorily completed the formal training and on-the-job training as a Radiographer's Assistant with Law Engineering. He will have received copies of and instructions in the regulations contained in the Safety Manual (*) and shall have demonstrated understanding thereof. He will have demonstrated competence to use the source of radiation, related handling tools, and survey instruments which will be employed in his assignment.

3. Radiographers With Previous Training

Individuals who have been a radiographer for another licensee, will verify competency to act as a radiographer for Law Engineering. The individual will provide the records from previous employers verifying training and experience comparable to that required by Law Engineering. He will have received copies and instructions in the regulations confirmed in the Safety Manual (*) and shall have demonstrated competence to use source of radiation, related handling tools, and survey instruments which will be employed in his assignments.

4. Radiographer's Assistant

All candidates for the position of Radiographer's Assistant should be given formal training in the use of sealed sources and x-ray equipment in industrial radiography. This training will be administered by the RSO and/or a qualified firm whose program meets the minimum standards as set forth by this procedure. He will have received copies and instructions in the regulations confirmed in the Safety Manual (*) and shall have demonstrated understanding thereof. He will have also demonstrated competence to use, under the personal supervision of the Radiographer, the sources of radiation, related handling tools and radiation survey instruments which will be employed in his assignments.

D. FORMAL TRAINING

All candidates for the positions of Radiographer or Radiographers Assistant will be given formal training. This formal training will be administered by the RSO and/or a qualified consultant in accordance with Law Engineering's Radiographic Manual. A minimum of 40 cumulative hours will be considered as minimum formal training prior to examination.

E. WRITTEN EXAMINATION

A written examination will be given all applicant Radiographers, Radiographers with previous training, and Radiographers Assistants upon completion of the training program. This examination is to determine their knowledge and understanding of, and ability to comply with, the Company's Administrative Control and Radiological Protection Procedures, States' Regulatory Commission's Regulations and all Agreement States Regulations. The applicant will not be permitted to refer to any reference manual during the test.

The examination shall consist of a minimum of fifty questions and problems. A score of 90% will be considered a minimum passing grade. If the applicant makes less than 90% on the examination, he may either retake the examination or receive additional instruction before re-examination at the discretion of the examiner. If the applicant makes less than 75% on the examination, he will receive an additional four (4) hours of formal training. He will then be re-examined. A re-examination score of 90% will be considered a minimum passing grade. The results of the examination will be kept on file. All missed examination questions will be reviewed with the applicant.

F. ON-THE-JOB TRAINING

Upon satisfactory completion of the formal training program and the examination, all Radiographer Assistants will be required to work with the experienced Radiographers for a period of not less than three months.

G. PRACTICAL EXAMINATION

For a period of one week, the prospective Radiographer and radiographers with previous training and experience with another employee will assume the responsibility for conducting the radiographic operations. His conduct will be closely observed by the Radiographer and then discussed with the RSO at the end of the trial period. If it is determined that the candidate has demonstrated his knowledge and ability to comply with the radiation safety rules, competency in the use of the exposure devices and related radiation monitoring equipment, he will then be considered qualified as a Radiographer. Frequent inspections by an experienced Radiographer will be made of this individual's radiographic operations during the first year of employment.

H. PERIODIC TRAINING

A formal review of the training course of one day's duration will be conducted by the Safety Officer at least once a year or more frequently when deemed necessary by the RSO. This training shall be documented.

(*) The Safety Manual will contain as a minimum the following:

1. The applicable Agreement State Regulations.
2. The NRC Title 10, Parts 19, 20 and 34.
3. Training Program.
4. Administrative Controls.
5. Operating Emergency Procedures.

SECTION III.B

TRAINING MANUAL

SECTION III.B

TRAINING MANUAL

A. FUNDAMENTALS OF RADIATION SAFETY

1. Characteristics of Radiation

We are authorized by the Nuclear Regulatory Commission and Agreement State to possess radioactive isotopes, Iridium 192 and Cobalt 60. In addition, two other commonly used radioactive isotopes, Cesium 137 and Radium, will be discussed.

These radioactive materials emit beta and gamma radiation as the radioactive atoms decay to stable atoms, that is, to the nonradioactive state. In addition, radium also emits alpha radiation in decaying to the stable state. The radioactive gaseous element, radon, is included in the decay scheme of radium, whereas Cesium 137, Iridium 192 and Cobalt 60 do not change from the solid state in the decay process. The gamma radiation from these radioactive sources will not cause materials commonly used in industrial radiography to become radioactive. This is not to be confused with radioactive contamination of an object which involves the actual deposition of a radioactive material on it.

The alpha and beta radiation from these radiographic sources have very limited penetrating power in matter and, for the most part, are absorbed in the capsule in which the radioactive materials are sealed. Gamma radiation, however, is highly penetrating. This makes it useful for radiography and also accounts for the potential external radiation hazard which is associated with the use of these materials. Gamma rays are similar in physical properties to X-rays, but differ in their origin. Gamma rays are emitted from unstable nuclei of atoms, whereas X-rays originate in the orbital electron system outside of the atomic nuclei.

2. Terms and Definitions

The REM 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 of X-rays. One millirem (mREM) = 0.001 REM. When considering personnel exposure, the term milliroentgen (mR), which is 1/1000 of a roentgen, is generally used.

The roentgen (R) is the unit of measurement of X-rays and gamma rays absorbed in air. It is a measure for the absorption of X and gamma radiation in the same sense that feet or inches are measures of length, and pounds a measure of weight. The roentgen represents a rather large quantity of absorbed radiation being about the amount which would be received in one hour at a point 3 feet from an unshielded capsule containing a gram of radium. The often used work "dose" refers to the number of roentgens received while "dose rate" indicates dose received per unit of time.

The curie (Ci) is a unit of activity for measuring the quantity of a radioactive material. The curie may be defined as that quantity of radioactive material which has 3.7×10^{10} nuclei disintegrating per second. A millicurie (mCi) is 1/1000 of a curie.

Each disintegrating atom in decaying to the stable state may or may not emit a gamma ray or it may give off more than one gamma ray, depending upon the properties of the atomic nuclei. For example, two gamma rays are emitted for each disintegrating atom of Cobalt 60, whereas one gamma ray is associated with 95 percent of the Cesium 137 atoms decaying.

The term "half life" refers to that period of time in which a given quantity of a specific radioactive isotope will decay to an activity equal to one-half of the original activity. After two half-life periods, only one-quarter of the original activity will remain, and so on.

Table I gives data on the radioactive characteristics of Radium, Cesium 137, Cobalt 60 and Iridium 192.

TABLE I
CHARACTERISTICS OF RADIOACTIVE MATERIALS USED IN INDUSTRIAL RADIOGRAPHY

Radioactive Material	Half Life	Gamma Rays, Mev*	Gamma Dose Rate Per Curie rhm**
Radium 226	1620 yrs	11 principal gammas, 0.24 to 2.20	0.84***
Cesium 137	33 yrs	0.66	0.39
Cobalt 60	5.2 yrs	1.17 and 1.33	1.35
Iridium 192	74 days	12 gammas reported, 0.21 to 0.61	0.55

* Million electron volts
** Roentgens per hour at 1 meter
*** Radium in equilibrium with decay products & sealed in platinum capsule having 0.50 mm wall thickness

3. Leak Testing

The Commission and Agreement States require that all by-product material covered by Law Engineering Testing Company's License be tested for leakage and/or contamination as follows:

Each sealed source shall be tested for leakage at intervals not to exceed six (6) months. In the absence of a certificate from a transferor that a test has been made within the six (6) months prior to the transfer, the sealed source shall not be put in use until tested.

All leak testing of sealed sources will be accomplished with a Wipe Test Kit which will be procured from Gamma Industries, Inc., Technical Operations, Inc., or other approved vendors. The leak test is to be performed only by a qualified Radiographer, in accordance with the applicable appendix of our Administrative Control and Radiological Protection Procedures.

4. Hazards of Excessive Exposure to Radiation

Absorption by cells of the human body of X or gamma radiation can result in their damage or possible destruction. The human body can tolerate a certain amount of exposure to gamma radiation without impairing the overall function of the body, just as it can tolerate a certain amount of direct exposure to sunlight without deleterious effects. We are continuously exposed to ionizing rays from natural sources, such as cosmic radiation or radiation from radioactive materials present in surrounding soil and atmosphere. At sea level, the exposure from natural sources is on the order of 1.5 milliroentgens per week.

Damage of cells or tissues may be permitted locally if medical benefit is to be derived from the exposure. For example, X-rays and radioactive materials are commonly used in the field of medicine to destroy cancerous tissue. Such medical uses are prescribed by physicians and radiation is administered under carefully-controlled conditions. When no medical benefit is to be derived from exposure to radiation, every effort should be made to keep personnel exposure as low as possible.

A question frequently encountered concerns the likelihood of sterility resulting from the radiation exposures normally received during radiographic operations. This likelihood is remote in that single doses of 600 to 800 roentgens in the testes are required to produce sterility in the male. On the other hand, a whole-body dose of 450 roentgens received in a short period of time would kill approximately 50 percent of the persons receiving such an exposure. A radiographer generally receives a small fraction of a roentgen in a week.

Maximum permissible exposures of an individual to radiation are detailed in the Company Administrative Control and Radiological Protection Procedures, and applicable NRC and Agreement States Regulations.

5. Levels of Radiation from Radioisotopes

As described earlier, different radioisotopes have different activity levels. The following table (Table II) lists four (4) radioisotopes and the intensity of each at various distances. This intensity is the dose rate (R/hr) at the distances listed per curie or (R/hr/Ci).

TABLE II

	DISTANCE FROM SOURCE						
RADIOISOTOPE	1 METER	1 FT	2 FT	4 FT	8 FT	16 FT	32 FT
Cobalt 60	1.35	14.5	3.6	0.9	0.23	0.06	0.014
Radium 226	0.84	9.0	2.3	0.6	0.14	0.035	0.009
Iridium 192	0.55	5.9	1.5	0.4	0.09	0.023	0.006
Cesium 137	0.39	4.2	1.1	0.26	0.07	0.016	0.004

6. Methods of Controlling Radiation Dose

Working Time: The total radiation exposure received by a person in a given field of radiation will depend upon the length of time that he stays there. For example, a person remaining in a given field of radiation for 5 minutes would receive only one-half as much exposure as he would in 10 minutes. If it is not possible to control exposure by varying working distances or using shielding, exposure must be controlled by limiting working time. Control of personnel exposure by limiting working time may require the rotation of workers.

This first fundamental appears also in determining the permissible working time in a given field of radiation, based upon the permissible weekly exposure value. The allowable working time can be obtained by applying the following equation:

$$\text{Allowable Working Time} = \frac{\text{Permissible Exposure (mR/wk)}}{\text{Exposure Rate (mR/hr)}}$$

Example:

Permissible exposure = 90 mR/wk
Exposure rate at radiation boundary = 2 mR/hr
Allowable working time = $\frac{90 \text{ mR/wk}}{2 \text{ mR/hr}}$ = 45 hr/wk

Working Distance: The farther from a radiographic source a person can work, the lower will be his exposure for any given period of time. The dose rate from a radiographic source decreases with distance in the same manner that the intensity of light decreases as a person moves farther from the light source.

The amount the dose rate decreases varies inversely with the square of the distance or:

$$\frac{I_1}{I_2} = \frac{D_2^2}{D_1^2}$$

Where: I_1 = the intensity or dose rate at D_1 and I_2 = the intensity or dose rate at D_2.

Example 1:

If the dose rate at 20 ft = 12 mR/hr, what would the dose rate be at 40 ft.

I_1 = 12 mR/hr

D_1 = 20 ft

I_2 = ?

D_2 = 40 ft

therefore $\frac{12 \text{ mR/hr}}{I_2} = \frac{(40)^2}{(20)^2}$

$$I_2 = \frac{D_1^2 \times I_1}{D_2^2}$$

$$I_2 = \frac{(400)(12)}{1600} = 3 \text{ mR/hr}$$

Example 2:

What would be the distance required from an unshielded 50 Curie Iridium 192 source to establish a 2 mR/hr boundary?

I_1 = (50 Ci) (5,900 mR/hr/Ci at one foot)
= 295,000 mR/hr

I_2 = 2 mR/hr

D_1 = 1 ft $\qquad D_2^2 = \dfrac{I_1 \times D_1^2}{I_2}$

D_2 = ? $\qquad D_2 = \sqrt{\dfrac{I_1 \times D_1^2}{I_2}}$

$$\frac{295{,}000 \text{ mR/hr}}{2 \text{ mR/hr}} = D_2^2$$

$$D_2 = \sqrt{\frac{295{,}000}{2}} = 385 \text{ feet}$$

Shielding: The use of shielding material affords an excellent means for controlling personnel exposure in radiographic operations. Shielding material is used to absorb or stop the radiation. Materials commonly used to shield gamma radiation are concrete, iron or steel and lead. Heavier materials such as these are more effective for shielding gamma radiation than are lighter materials such as aluminum and soil.

Density variations of specific materials as affected by porosity will change shielding characteristics.

Tenth-Value Thickness: The thickness of a shielding material which will reduce the amount of gamma radiation passing through the shield to one-tenth that of the radiation entering the shield is referred to as the tenth-value layer. This thickness varies, depending upon the shielding material and the energy of the gamma radiation in question.

The reduction factor resulting from the use of more than one tenth-value layer in a shield is the product of as many tens as there are tenth-value layers used. For example, a shield thickness equivalent to three tenth-value layers would give a reduction factor of 10 x 10 x 10 or 1000.

Half-Value Thickness: Another specific thickness which is convenient to use in shielding problems is the half-value layer. The half-value layer is that thickness of material which will reduce the radiation intensity one-half that entering the shield.

The procedure for making calculations using the half-value layer is the same as that demonstrated from the tenth-value layer except that the number two is used instead of ter.

The following table gives the approximate tenth- and half-value thickness for various materials which may be used for shielding radiation from Cobalt 60, Radium 226, Iridium 192 and Cesium 137.

TABLE III

Approximate Tenth- and Half-Value Layer Thicknesses for Various Shielding Materials

	THICKNESS IN INCHES OF:					
	LEAD		IRON		CONCRETE*	
RADIOISOTOPE	1/10	1/2	1/10	1/2	1/10	1/2
Cobalt 60	1.62	0.49	2.90	0.87	9.0	2.7
Radium 226	1.85	0.56	3.03	0.91	9.6	2.9
Cesium 137	0.84	0.25	2.25	0.68	7.1	2.1
Iridium 192	0.64	0.19	2.00	0.61	6.2	1.9

The thicknesses for tenth- and half-value layers provide shielding protection from the scattered radiation resulting from deflection of the primary gamma rays within the shield as well as protection from primary radiation from the source. The tenth-value thicknesses were taken as one-third the thickness of shielding material necessary to give a reduction factor of 1000. The half-value thickness is equal to the tenth-value thickness divided by 3.32.

*Density of concrete assumed to be 147 pounds per cubic foot.

B. RADIATION DETECTION INSTRUMENTATION

1. Use of the Victoreen Survey Meter Model 592

General Description: The instrument is designed to measure the intensity of X or gamma radiation of mixed energy spectra, in milliroentgens per hour, with an accuracy conservatively rated at plus or minus 10 percent of true dose over the energy range from 50 Kev to 1.3 Mev. Calibration is held well within 5 percent, but allowance is made for reading and zeroing errors. The ionization chamber is hermetically sealed to make it independent of altitude and air-density variations.

The Model 592 Gamma Survey Meter is particularly suited for monitoring radiation leakage around X-ray machines, for spot checks of many radiation sources, for monitoring during decontamination procedures, for monitoring of radioisotopes and all surveying for radiation hazards where a portable, highly-accurate instrument is required. An ionization chamber survey instrument is required for intensities greater than 1 mR/hr.

This is a battery-operated ion chamber instrument for the measurement of X and gamma radiation over the range of 1 to 1000 mR/hr at energies given in paragraph one above. Three linear ranges with full-scale sensitivities of 1000, 100, and 10 mR/hr are provided. A rugged fiberglas reinforced case houses the components and ion chamber assembly. The case has a top and bottom section held together by two Dzus fasteners. The meter, two controls and a carrying handler are on the top surface of the instrument.

The meter is graduated from 0 to 10 mR/hr. The Off/On selection switch knob and zeroing control knob are located to the left and right of the carrying handle at fingertip reach. Three range positions, X100, X10 and X1 are marked on the case top. A guard ring protects the zeroing knob against accidental displacement.

Reference Data:

Range	- 0-10, 0-100, 0-1000 mR/hr
Energy Range	- 50 Kev to 1.3 Mev.
Accuracy	- 10% at full scale (0.05 to 1.3 Mev.)
Battery Complement	- 2 RM-4 Mercury Cells, 1.3 Volts Each 10 No. 412 Eveready 22.5 Volt Batteries
Battery Life	- 300 hours
Weight	- 4-3/4 lbs. Shipping Weight, 12 lbs. (approx.)

Operation: The Gamma Dose Rate Meter, Model 592, is a portable ion chamber survey instrument for the measurement of X and gamma radiation over the range of 1 to 1000 mR/hr at energies between 50 Mev and 1.3 Mev. Three linear ranges with full sensitivities of 1000, 100 and 10 mR/hr are provided.

There are two external controls on the case: a five-position range switch to the left of the carrying handle, and a zero adjustment control to the right of the handle. The five positions of the range switch are Off, Zero, X100, X10 and X1. In the OFF position, all batteries are disconnected.

Operating Steps: The operating steps are as follows:

1. Turn the range switch to the Zero position.

2. Adjust the zero control (the right-hand control) so that the meter reads exactly zero. In the zero position, the input has been switched to a reference potential and the instrument has been switched to a maximum sensitivity of X1, which allows accurate zeroing in a radiation field.

3. Turn the range switch to the X100, X10 or X1 range, as required, and the instrument will measure gamma radiation in mR/hr.

Each time the instrument is turned off it is advisable to zero the meter again when a new measurement is to be made, unless such measurement is made using the X100 or X10 range. This applies to situations where frequent measurements are made, as in surveys.

2. Use of the Eberline Geiger Counter, Model E510G

Description of Controls

SCALE SWITCH: This four-position control combines the function of turning the instrument ON and selecting the desired scale and proper meter response. The control is marked OFF, X100, X10 and X1.

RESET: By pressing the reset button, the meter pointer can be rapidly zeroed after a reading has been taken. This decreases the delay due to slow meter response on the lower scale.

BATTERY CHECK: Battery voltage may be checked by depressing the BATT. CHECK switch and observing the meter. The meter should read within the green portion.

Meter Reading Interpretation

To read the gamma field strength, it is necessary to multiply the meter reading by the number indicated by the scale switch. If the scale switch is set on X10, and the meter reads 6, the gamma field strength would be this 6 multipled by 10, or 60 mR/hr.

Radiation is random in nature and when the instrument is in a radiation field, there will be a slow movement of the meter pointer. This movement is due to the randomness of the photon or particle. Observe the meter for a sufficient period of time to determine the average reading. This is best done by observing a high reading, waiting until the reading drops off to a low value and returns to another high value and taking the average between the two extremes as the proper meter reading.

Monitoring for Gamma Radiation

Set the scale switch on the X100 position. If the meter does not read upscale, continue moving the scale switch to the lower multiplier until an upscale reading is obtained. When the proper scale has been selected, observe the meter action long enough to define the average reading.

3. Use of the Eberline Survey Meter, Model E130G

Description of Controls

SCALE SWITCH: This four-position control combines the function of turning the instrument ON and selecting the desired scale and proper meter response. The control is marked OFF, BATT, X100, X10, X1.

RESET: By pressing the reset button, the meter pointer can be rapidly zeroed after a reading has been taken. This decreases the delay due to slow meter response on the lower scale.

BATTERY CHECK: Battery voltage may be checked by turning the control to "BATT" and observing the meter. The meter should read within the zone marked "battery check."

Meter Reading Interpretation

To read the gamma field strength, it is necessary to multiply the meter reading by the number indicated by the scale switch. If the scale switch is set on X10, and the meter reads 6, the gamma field strength would be this 6 multiplied by 10, or 60 mR/hr.

Radiation is random in nature and when the instrument is in a radiation field, there will be slow movement of the meter pointer. This movement is due to the randomness of the photon or particle. Observe the meter for a sufficient period of time to determine the average reading. This is best done by observing a high reading, waiting until the reading drops off to a low value and returns to another high value and taking the average between the two extremes as the proper meter reading.

Monitoring for Gamma Radiation

Set the scale switch on the X100 position. If the meter does not read upscale, continue moving the scale switch to the lower multiplier until an upscale reading is obtained. When the proper scale has been selected, observe the meter action long enough to define the average reading.

4. Use of the Gamma Industries, Model 200D

The Gamma Industries, Model 200D, is a survey meter designed to detect and measure gamma radiation levels of 0 to 2000 mR/hr. The instrument is controlled by one five-position switch, which has the following positions: OFF, TEST, X100, X10, and X1.

Battery Test

At the beginning of each work day, and periodically throughout the day, a battery test should be performed. To perform the battery test, place the control switch in the TEST position. A meter reading of at least 13 should be obtained. If not, the batteries should be replaced.

Survey Meter Operation

To measure the radiation intensity in a gamma radiation field, set the control switch of the survey meter to the X100 position. If no indication is obtained, continue moving the control switch to the next lower scale (X10, X1) until a reading is obtained.

To determine the radiation intensity you are measuring, multiply the meter reading by the value of the control switch setting (i.e., if the meter reading is 8 and the control switch setting is X10, the radiation intensity is 80 mR/hr).

Radioactive decay is a random process. When the instrument is in a radioactive field, there will be a slow, continuous movement of the meter pointer. Observe the meter for a sufficient amount of time to determine an average reading.

5. Use of the Victoreen, Model 492

The Victoreen Instrument Division, Model 492, is a survey meter designed to detect and measure gamma radiation levels of 0 to 1000 mR/hr. The instrument is controlled by one five-position switch, which has the following positions: OFF, BAT., X100, X10, and X1.

Battery Test

At the beginning of each work day, and periodically throughout the day, a battery test should be performed. To perform the battery test, place the control switch in the TEST position. A meter reading of at least 7 should be obtained. If not, the batteries should be replaced.

Survey Meter Operation

To measure the radiation intensity in a gamma radiation field, set the control switch of the survey meter to the X100 position. If no indication is obtained, continue moving the control switch to the next lower scale (X10, X1) until a reading is obtained.

To determine the radiation intensity you are measuring, multiply the meter reading by the value of the control switch setting (i.e., if the meter reading is 8 and the control switch setting is X10, the radiation intensity is 80 mR/hr).

Radioactive decay is a random process. When the instrument is in a radioactive field, there will be a slow, continuous movement of the meter pointer. Observe the meter for a sufficient amount of time to determine an average reading.

6. Use of the Eberline Survey Meter, Model E120G

Description of Controls

SCALE SWITCH: This four-position control combines the function of turning the instrument ON and selecting the desired scale and proper meter response. The control is marked OFF, BATT, X10, X1 and X0.1.

RESET: By pressing the reset button, the meter pointer can be rapidly zeroed after a reading has been taken. This decreases the delay due to slow meter response on the lower scale.

BATTERY CHECK: Battery voltage may be checked by turning the control to "BATT" and observing the meter. The meter should read within the zone marked "battery check".

Meter Reading Interpretation

To read the gamma field strength, it is necessary to multiply the meter reading by the number indicated by the scale switch. If the scale switch is set on X10, and the meter reads 6, the gamma field strength would be this 6 multiplied by 10, or 60 mR/hr.

Radiation is random in nature and when the instrument is in a radiation field, there will be a slow movement of the meter pointer. This movement is due to the randomness of the photon or particle. Observe the meter for a sufficient period of time to determine the average reading. This is best done by observing a high reading, waiting until the reading drops off to a low value and returns to another high value and taking the average between the two extremes as the proper meter reading.

Monitoring for Gamma Radiation

Set the scale switch on the X10 position. If the meter does not read up-scale, continue moving the scale switch to the lower multiplier until an up-scale reading is obtained. When the proper scale has been selected, observe the meter action long enough to define the average reading.

7. Calibration of instruments

Instruments will be calibrated using the following procedures.

a. Calibrations of survey meters should be performed with radionuclide sources. (Neither electronic calibrations that do not involve a source of radiation nor the use of small check sources such as those incorporated into some survey meters are acceptable for calibration.)
b. The sources should be approximate point sources.

c. The activity of the source or exposure rates at given distances should be traceable by documented measurements to a standard source certified within 5% accuracy by the U.S. National Bureau of Standards (NBS) or other recognized standards laboratory.

d. Instruments should be calibrated at least each 90 days and after servicing.

e. Each scale of an instrument should be calibrated at at least two points located at approximately 1/3 and 2/3 of full scale. For logarithmic rate-changing instruments, the calibration should be made near the mid-range of each decade, and two points should be calibrated on at least one of the decades.

f. The exposure rate measured by the instrument being calibrated should differ from the true exposure rate by less than ±10% at the calibration points. (Read the appropriate instrument manual to determine how to make the necessary adjustments to bring the instrument into calibration.) Readings within ±20% will be considered acceptable if a calibration chart, graph, or response factor is prepared and used with the instrument to interpret meter readings to within ±10% for radiation protection purposes.

The calibration of survey instruments should be accomplished only by trained and approved personnel.

8. Survey Techniques

Survey techniques described in our Company Administrative Control and Radiological Protection Procedures will be discussed in detail. Using Table II in this training program and the inverse square law, it will be shown how to determine the source to rope barrier distance prior to exposing the source. Actual setups will be made and the areas surveyed. In addition, a lost source demonstration will be simulated and the correct method of surveying the area and locating the source will be shown. Each individual shall at this time be required to demonstrate this competency in the use of the survey meter.

C. USE OF PERSONNEL MONITORING EQUIPMENT

Thermoluminescent Dosimetry (TLD): One January 1, 1971, Law Engineering began using TLD badges as a replacement of the film badges then in use. All subsequent references to film badges in this manual will relate to the use of TLD badges. Film badges are supplied by Eberline Instruments Corporation, Santa Fe, New Mexico 87501.

A TLD badge consists of a small chip of Lithium Fluoride and filter media in an outer case which discriminates between different energy ranges. Each Radiographer and Radiographer Assistant wears a TLD badge for one month. It is then returned to the supplier for processing and reporting. This "instrument" totalizes or measures accumulated dosage. An advantage is that a record is kept that cannot be altered or lost through negligence of reading and recording. A disadvantage of the TLD badge is that the dosage cannot be determined until after the TLD has been processed. Consequently, we are required to wear a pocket dosimeter in conjunction with the TLD badge. A record of the dosimeter readings is to be recorded at the end of each day.

Dosimeters: The pocket dosimeter differs from the indirect reading type because it may be read directly by the wearer at any time. The dose is read on an internal scale built into the dosimeter and can be illuminated by an external light source, such as an electric light. The dosimeter has a built-in string electronmeter and ion chamber. A minimum range of 0 to 200 mR is required for normal radiographic work. Dosimeters with a range of 0 to 1,000 or 2,000 may be worn if deemed necessary. A dosimeter charger is used to impress a charge of this ion chamber. A zero position on the built-in scale will indicate that the dosimeter is fully charged. The dosimeter should be charged to as near zero as possible. Radiation passing through the chamber will cause the charge to leak off in proportion to the amount of radiation and move the electronmeter string up-scale accordingly. This up-scale position indicates the amount of radiation exposure. Recharging of the chamber after each reading is not required.

D. THE USE, INSPECTION AND MAINTENANCE OF LAW ENGINEERING RADIOGRAPHIC EXPOSURE DEVICES

The sections V and VI of our Administrative Control and Radiological Protection Procedures contains the handling and operation of exposure devices and will be discussed in detail. The proper operation of the projectors in our possession at the time will be demonstrated. The individuals so instructed shall at this time be required to demonstrate competency in the use of these projectors. In addition, the use of the Wipe Test Kit will be discussed as outlined in the said appendix.

Included within the Radiation Safety Manual will be pertinent Federal and State regulations and operating and emergency procedures. These requirements and procedures will be thoroughly discussed with the trainee.

E. CASE HISTORIES OF RADIOGRAPHY ACCIDENTS

Bulletins and descriptions are available upon request to the Corporate Office reflecting current information.

SECTION IV.

ADMINISTRATIVE CONTROLS AND RADIOLOGICAL PROTECTION PROCEDURES

SECTION IV

ADMINISTRATIVE CONTROL & RADIOLOGICAL PROTECTION PROCEDURES

RESPONSIBILITY FOR THE CONTROL & USE OF ISOTOPES

PRESIDENT

BY-PRODUCT MATERIALS LICENSING COORDINATOR

RADIATION SAFETY OFFICER

SPECIFIC DUTIES

1. Develop & maintain up-to-date operating & emergency procedures.

2. Establish, maintain & audit a personnel monitoring program.

3. Conduct the established training program for Radiographers & Radiographer's Assistants.

4. Examine & determine competency of Radiographic personnel.

5. Establish, maintain & audit the recordkeeping system & instrument calibration program.

6. Reports directly to the President or, in his temporary absence, the BMLC.

ADVISORY DUTIES

1. Maintain technical liaison with the NRC, and Agreement States.

2. Investigate cause of incidents & determine necessary preventive action.

3. Report all incidents to the Commission Nuclear Regulatory & State Health Department.

4. Act in advisory capacity to management reporting directly to the President or, in his absence, the BMLC.

BRANCH MANAGER

1. Maintain control of procurement & disposal of licensed by-product material.

2. Establish & maintain adequate storage facilities.

3. Maintain exposure devices, radiographic facilities & associated equipment.

4. Responsibility for the source replacement operations.

5. Procure & maintain adequate radiation survey instruments.

6. Review & insure safety in handling of by-product material.

7. Maintain branch level files.

8. Audit facilities & personnel operations.

(RADIOGRAPHIC TECHNICIANS)

(1) Radiographer (2) Radiographer's Assistant

POSITION INCUMBENTS
CHART OF RESPONSIBILITY FOR THE CONTROL & USE OF ISOTOPES

EFFECTIVE MARCH 1, 1987

PRESIDENT	W. T. Kiser	Office	404/396-8000
		Home	404/451-5084
BY-PRODUCT MATERIALS LICENSE COORDINATOR	G. F. Miller	Office	404/396-8000
		Home	404/979-5347
WASHINGTON RSO	G. A. Lilley	Office	703/968-4700
		Home	703/791-6569
WASHINGTON BRANCH MANAGER	W. R. Mosher	Office	703/968-4700
		Home	301/997-1564

A. OFFICE OF THE PRESIDENT

The President is directly responsible for the overall radiation protection program through the By-product Material Licensing Coordinator. He will be responsible to designate responsible and qualified individuals as Radiation Safety Officers. The Radiation Safety Officer shall report directly to the Office of the President.

The Office of the President through the By-product Material Licensing Coordinator will be responsible to keep up-to-date NRC and Federal regulations and pertinent information from other Federal Departments for distribution to applicable personnel.

B. RADIATION SAFETY OFFICER

The Radiation Safety Officers (RSO) shall make unannounced periodic visits and observe the performance of every radiographer and radiographer's assistant in the field at least once every three months. In the event a radiographer, or radiographer's assistant does not perform radiography for a period exceeding three months, then the audit will be carried out the first time that person engages in radiographic operations.

The RSO will check required records maintained at all Branch Offices. They will report their findings in writing to the President and to Branch Managers. Branch Managers will reply in writing to the RSO and the President stating details of corrective actions taken to any deficiencies found during the RSO's inspection.

The President will see that all RSO's submit their quarterly audit reports in a timely and efficient manner. The President shall review all items of non-compliance reported and will be assured that corrective actions are taken.

The RSO will also report to the By-product Material Licensing Coordinator in writing:

- Any incident.
- Report of any suspected incident involving radioactive materials when first informed.
- Report of individuals whose dosimeter went off scale, the reason, and the film badge reading.
- Record of wipe test on any sealed source that was in use and six months due date exceeded.
- Report of weekly compiled dose rates for any Radiographer with 100 mR or more per week.
- Copy of monthly TLD badge readings, including totals to date, for any Radiographer with a reading of 300 mR or more per month.

C. BRANCH MANAGER

The Branch Manager shall be responsible to assign through his office or department individuals to maintain and control those duties specified in the chart on page 1 of this section of the Manual. It will be his responsibility to see that these duties are being carried out through unannounced audits of his facility and personnel.

D. RADIOGRAPHIC TECHNICIANS

1. Radiographer

A Radiographer will have satisfactorily completed the Company's safety program as detailed in the Safety Procedure and Manual. He will perform or be in attendance at the site where the sealed source(s) are being used. He will be responsible to personally supervise radiographic operations. He will be responsible to the licensee for assuring compliance with the requirements of the NRC and States regulations and the conditions of the license.

2. Radiographer's Assistant

A Radiographer's Assistant will have satisfactorily completed the Company's safety program as detailed in the Safety Procedure and Manual. He will use radiographic exposure devices sealed sources or related handling tools, or radiation survey instruments in radiography under the personal supervision of a Radiographer.

SECTION V

GENERAL SAFETY REGULATIONS

SECTION V

GENERAL SAFETY REGULATIONS

A. MAXIMUM PERMISSIBLE EXPOSURE

Based on NRC Standard, Part 20, paragraph 20.101 (1), radiographic personnel working in radiography full time shall not be exposed for more than 18 mREM per day or 90 mREM per week (based on an 8-hour day, 5-day week). In no case will radiographic personnel receive more than the quarterly or life-time dose detailed in Part 20.

For non-radiographic personnel over 18 years of age, the maximum permissible exposure is not to exceed 2 mREM in any one hour or 100 mREM in any one week.

For all individuals under 18 years of age, the maximum permissible exposure is not to exceed 10 percent of the limits specified in the tables in paragraph 10 (a) of NRC, Part 20.

The limits set forth above are to be considered as a maximum guidance only and not as a working level to be followed routinely.

B. PERSONNEL MONITORING

Film badges will be assigned to each Radiographer and worn at all times when working with or transporting radioisotopes. Film badges will be worn for a period of one month starting on the first day and ending on the last. Film badges will then be returned for processing.

In addition to film badges, pocket dosimeters with a range of 0 to 200 milliroentgens will be assigned to all Radiographers and will be worn at all times when working with or transporting radioisotopes. Dosimeters should be read frequently during the work day and readings recorded at the end of each day on forms provided for this purpose. Dosimeters should be reset to zero routinely to avoid those accumulations which may approach 200 mR. Pocket dosimeters will be checked for accuracy at least once each year.

In the event of an incident where a dosage in excess of 200 mR is indicated on the dosimeter or is suspected to have occurred, the film badge will be immediately returned for processing. The Radiographer involved will not be allowed to continue working with radioisotopes until the Radiological Safety Officer ascertains the exposure involved and advises whether corrective action is necessary. The film badge suppliers will be promptly notified by telephone of the rush return of the film badge to expedite processing and reporting results.

A weekly report of dosimeter readings will be executed in duplicate on the forms provided, with the original sent to the Radiation Safety Officer at the end of the week and the duplicate retained in the originating office (this may be the same office in which case only one report needs to be completed).

C. SURVEY METERS

A radiation survey meter capable of measuring from two mR/hr to one R/hr will be used to monitor the area where radioisotopes are being used or stored. The survey meter will be maintained in a calibrated and operable condition at all times. The survey meters will be calibrated at least annually, and after each repair. The calibrated meter shall be calibrated using procedures in Section III.B

A physical radiation survey is to be made after each radiographic exposure during a testing operation to verify that the sealed source has been returned to its shielded condition. Of particular importance is a survey of the guide tube of remote control devices and the exposure part of self-contained devices. This survey is to be performed around the entire circumference of the exposure device.

A physical radiation survey is to be made to determine that each sealed source is in the shielded condition prior to securing the radiographic exposure device and/or storage container.

D. RADIATION SURVEY OF WORKING AREAS

The immediate area where the radiographic test is to be made will be cleared of all non-radiographic personnel and roped off where no unmonitored personnel can receive more than 2 mR in any one hour. Radiation signs will be posted at this boundary. If the area cannot be roped off in a practical manner, a Radiographer shall be stationed to prevent entry of unauthorized personnel. Radiation area signs will be placed in the unroped areas and at applicable entry points to the unroped areas.

Survey the boundary established by the rope barrier and adjust the rope areas so that no unauthorized personnel outside the roped area will receive more than 2 mR in any 1 hour or more than 100 mR in one week.

Complete all details on the monthly radiation survey forms that are provided, in duplicate, and send the original to the assigned RSO at the end of each month. Retain the duplicate in the originating office.

If a number of exposures are to be made at one location within the same area, it is not required to complete an area survey form for each exposure. However, the restricted area must be surveyed and results of that survey recorded each day. This survey is routinely conducted at the beginning of each day.

The restricted area will be kept under continuous surveillance during each exposure by either the Radiographer or his Assistant.

Never, under any circumstances, will a restricted area or an unlocked exposure device be left unattended.

E. TRANSPORTING OF EXPOSURE DEVICES

Prior to transporting an exposure device by car or truck, a radioactive materials transportation form will be filled out, and will include type of materials transported, where transported to and from, and vehicle surface survey results. When it is necessary to transport an exposure device in a car, approved "RADIOACTIVE" Department of Transportation radiation signs will be posted on the four sides of the vehicle. These signs must be kept clean and clearly visible at all times. The device must be so secured that it cannot shift or fall and create a hazard in the event of an accident. An "IN CASE OF EMERGENCY" radiation sign must be attached to your dash to insure notification to the proper authorities in the event of an accident. The radiation level at the exterior of the vehicle and inside the passenger compartment of the car cannot exceed 2 mR/hr. The vehicle will be locked at all times when not personally attended.

When transporting an exposure device by truck, the device must be securely contained in outer overpack and so secured that it cannot shift or fall and create a hazard in the event of an accident. Radiation levels cannot exceed 2 mR/hr. in the passenger compartment. Approved "RADIOACTIVE" Department of Transportation radiation signs must be posted, one in the back, one in the front, and one on each side of the truck. These signs must be kept clean and clearly visible at all times. An "IN CASE OF EMERGENCY" radiation sign must be attached in the event of an accident. The vehicle will not be left unattended unless the exposure device is locked inside the cab of the vehicle.

F. PROCEDURES FOR PICKING UP, RECEIVING AND OPENING PACKAGES

When any of Law Engineering's operations expect to receive a package(s) of radioactive material, the following action will be taken:

- If the package is to be delivered to your facility by the carrier, make arrangements to receive the package when it is offered for delivery by the carrier.

- If you are to pick up the package at the carrier's terminal, make arrangements to receive notification from the carrier of the arrival of the package at the time of arrival. Upon notification, the package will be picked up expeditiously to comply with all transportation regulations.

- Upon the receipt of the package, you shall monitor the radiation levels external to the package immediately. This monitoring will be done at the carrier's terminal or point of delivery.

- If radiation levels are found on the external surface of the package in excess of 200 mR/hr or at 3 ft from the external surface of the package in excess of 10 mR/hr, you shall immediately notify, by telephone and telegraph, the final delivering carrier and the appropriate Nuclear Regulatory Commission and State Health Department Office.

- If the radiation levels are found to be less than those mentioned in paragraph 4 above, you may proceed with opening the package as follows:

  Cut the wire tag which locks the lid on the shipping container.

  Remove packing slip and verify the contents of the container with that of the order and that the wipe test was performed prior to the container leaving the supplier.

  In the event that the device is a remote control unit, remove the source changer from the shipping container and proceed with the source changing procedure as outlined in this Section.

G. PROCEDURES FOR CLOSING AND SHIPPING OF PACKAGES

When radioactive material is to be shipped, the following procedures shall be followed:

- Inspect the exposure device or source chaning device to verify, rather than assure, that the sealed source is in the locked position.

- Monitor the device prior to its placement into the shipping container to confirm that the radiation level is within the limits specified in 10 CFR Part 34.21.

- Place the device into the shipping container making sure that the container is properly lined to prevent excessive movement of the device during shipment. Include within the container specific information identifying the source as to type, activity and serial number and the serial number and the serial number of the device and a copy of the leak test certificate.

- Secure the lid of the shipping container with a wire seal and affix labels indicating the Transport Index, source type and source activity on outside surface of the container.

- Prior to the consignment of the package to a carrier, monitor the exterior surface of the shipping container. There shall be no level of radiation in excess of 200 mR/hr at any exterior surface, and 10 mR/hr at one meter from any exterior surface. In the event that the levels are in excess of these limits, the package is not to be shipped common carrier and the Radiation Safety Officer will be notified.

H. POSTING OF HIGH RADIATION AREAS

A "High Radiation Area" is defined as an area accessible to personnel in which there exists a radiation background at such levels that a major portion of the body could receive in any one hour a dose in excess of 100 mREM.

Each High Radiation Area shall be conspicuously posted with a sign(s) bearing the radiation symbol and the words: CAUTION--HIGH RADIATION AREA.

Positive and accountable control will be maintained over each individual entry to a "High Radiation Area". A person entering a High Radiation Area must carry a calibrated survey meter.

I. FIELD OPERATION PROCEDURES

In radiography, more than in any other operation, it is important to develop a systematic way of performing an assignment. The following list of procedures and materials should become a mental checklist used prior to each job. When this is done, it will lead to a safer and more productive job.

- Zero your dosimeter and record reading.

- Be sure you have your film badge.

- Check out operable survey meter.

- Check meter calibration date.

- Survey device assigned to job; surface radiation levels should not exceed 200 mR/hr anywhere. If they do, report to the RSO and/or Department Manager.

- Go over daily maintenance checkoff list.

- Fill out data on utilization log.

- See that device is locked and that lock plunger and safety cap are in place.

- Place source and device in truck so that vibration or bumps will not dislodge it or cause it to "walk."

- Survey exterior of vehicle. If radiation level exceeds 2 mR/hr, secure shielding around device.

- Be sure to have sufficient supplies to meet regulatory requirements. These should include:

  Caution: High Radiation Area signs

  Caution: Radiation Area signs

  Caution: Radioactive Material signs

  Rope or other barricade material

- Place the survey meter in the seat beside you and periodically check the radiation level. If an appreciable change is noted, the device has probably moved, so stop to resecure it, being sure to use the survey meter as much as possible.

- Upon arrival at field location, survey device to ascertain that source is still safely contained.

- Never leave the device unattended. If it is necessary for the Radiographer to leave the vehicle for any reason, the exposure device will be either guarded or securely locked in the vehicle. In the case of a truck, it may be locked inside the cab.

Making an Exposure:

- Using the inverse square law, calculate the approximate location of restricted area barricade.
- Pace off the calculated distance and mark the perimeter.
- Display "Caution--Radiation Area" signs prominently.
- A few paces inside of this barricade, position "High Radiation Area" signs.
- Place film on specimen (this may be done after the area is surveyed for confirmation of 2 mR/hr barricade).
- Remove device from truck and place in approximate location of use.
- Remove safety plug.
- Attach source tube to device.
- Position source tube as required.
- Remove pigtail protector cap.
- Attach control cable to pigtail.
- Screw control cable fitting into lock box.
- Try to have both source tube and control cables as straight as practical.
- You are now ready to expose source if the area is clear.
- Unlock device.
- Crank source out with a smooth easy motion.
- When you feel the source stop, it has reached the end of the source tube, and it is not wise to try to crank any further.
- Survey the perimeter of the restricted area and record results. Perimeter levels should not exceed 2 mR in any one hour.
- Keep personnel out of restricted area.
- Do not leave area unless surveillance is maintained by assistant.

- Retract source until a positive stop is felt.
- Survey and approach device with meter in hand.
- Hold meter at arms' length and survey the entire circumference of the source device and guide tube to be sure that the source has been returned to it's shielded position.
- Lock device.
- If this is last exposure, measure the level of radiation at the surface with camera in appropriate box and record reading dosimeter report.

Securing Area After Radiography:

- With survey meter at hand, disconnect source tube.
- Insert safety plug.
- Disconnect control cable.
- Screw in protector cap.
- Carry device to vehicle and secure.
- Gather source tube and control cable.
- Place survey meter on seat of vehicle.
- Take down barricade and signs.
- Pick up signs and return to vehicle.
- Return to laboratory.
- Return device to storage.
- Check device with survey meter.
- Record survey, giving radiation levels detected.

SECTION VI

OPERATING AND EMERGENCY PROCEDURES

SECTION VI

OPERATING AND EMERGENCY PROCEDURES

A. Safety Rules

B. Emergency Procedures

C. Notification of Incidents

D. Daily Maintenance Check of Radiographic Devices

E. Operation of Gamma Century

F. Operation of Gamma Pipeliner

G. Operation of Gamma Gammatron 20A and 100A

H. Operation of Amersham-Tech/Ops Model 660

I. Operation of Amersham-Tech/Ops Model 680

J. Inspection and Maintenance for Amersham-Tech/Ops Model 660

K. Inspection and Maintenance for Amersham-Tech/Ops Model 680

L. Inspection and Maintenance for Gamma Industries Century, 20A and 100A

M. Inspection and Maintenance for Gamma Pipeliner

N. Wipe Test for Gammatron 20A and 100A

O. Wipe Test for Gamma Pipeliner

P. Wipe Test for Amersham-Tech/Ops 660 and 680

Q. Inspection and Operation of Source Changers

R. Inspection and Operation of Source Changes for Amersham-Tech/Ops Model 660 and 680

A. SAFETY RULES

1. Dosage rate varies with the following:

   a. Distance - Greater distance - Less exposure
   b. Time - Less time - Less exposure
   c. Shielding - Thicker shielding - Less exposure

2. Radiographer Dosage

   a. Weekly - 90 mR
   b. Daily (5-day week) - 18 mR

3. Use warning signs and barriers. Monitor area to minimize exposure to others and self.

4. Always wear film badge and dosimeter.

5. In transit:

   a. The machine must always be permanently tagged with the following information:

      (1) Source, number of curies and date of calibration.

      (2) Company name, address and phone number.

   b. Keep machine in a locked area at all times except when in actual use.

   c. A warning sign must be displayed on the door of the area where the source is stored.

6. Complete dosage reports and survey reports daily.

7. Never retrieve dropped source with hands. Use rod, tongs or other type pickups.

8. Make certain source retainer screw is always tight. Always make certain camera door is closed and locked.

9. Make trial runs for time in new techniques.

10. Handle machine with care and do not damage in any way.

11. Do not always rely on calculated dosages.

12. Never remove the source from the exposure device by hand; never attempt to perform radiographic exposure using the open-air or free-source technique, i.e., where source is not physically or mechanically attached to the exposure device.

13. Formulas

    a. To find mR/hr for Iridium 192 at D, distance, multiply number of curies by 5900 and divide results by the square of the distance. For Cobalt 60, multiply curies by 14500 and divide results by the square of the distance.

    b. To find curies of Iridium 192, take the meter reading at 10 or 15 feet, multiply the meter reading by the square of the distance. The results are mR/hr at one foot. Divide this by 5900 which results in the number of curies. For Cobalt 60, divide mR/hr by 14500 rather than 5900.

14. Iridium 192 has an emission rate of 5.9 R (5900 mR) per hour per curie at a distance of 1 foot.

15. Cobalt 60 has an emission rate of 14.5 R (14500 mR) per hour per curie at a distance of 1 foot.

16. Remember:

    a. Radiation is invisible rays that cannot be detected by physical senses.

    b. Avoid entering the field of direct radiation.

    c. Plan your operations, make dummy runs when practical.

17. Always use common sense.

18. Never allow unqualified persons to handle isotopes.

19. Storage of sources and devices at job site in Non-Agreement States:

a. Job site storage of locked sources and devices will be in a locked building or locked radiographic trailer or vehicle and the area posted with CAUTION: RADIOACTIVE MATERIALS posters.

b. If locked building is used for storage and access to such building is available to persons other than the Radiographer and his Assistant, the source or device will be secured in a locked metal or locked substantial wooden box. The box will be posted with CAUTION: RADIOACTIVE MATERIALS posters.

c. The storage area will provide such protection that no person, if continuously present in the area, could receive a dose in excess of 2 mR in any one hour or 100 mR in any seven consecutive days.

B. EMERGENCY PROCEDURES

1. In the event of an accident to the source or device, such as a falling object hitting the device, immediately do the following:

   a. Return source to shielded position in the device if possible. Conduct physical radiation survey to assure source is fully shielded and lock device.

   b. Notify your supervisor, who shall in turn notify the Radiation Safety Officer or the Branch Manager in his absence.

   c. Do not use the device again until the Radiation Safety Officer has made an inspection of the device and personnel monitoring equipment and grants approval for its use.

   d. In the event the source cannot be returned to the device, immediately do the following:

      (1) Set up and post a restricted area, using a survey instrument to determine the perimeter of the area. If the survey instrument has been damaged, use the enclosed table to determine the perimeter.

      (2) Do not allow anyone to enter this area.

      (3) Notify your supervisor.

      (4) Continue to restrict entry into area.

      (5) Supervisor will notify the Radiation Safety Officer or the Branch Manager in his absence.

2. Vehicular Accident

   a. In the event of a vehicular accident involving by-product material while traveling to an exposure site, a restricted area must be set up and posted.

   b. If a survey meter is operable, use it to establish the perimeter of the restricted area.

c. If the survey meter is inoperable, use calculations or the enclosed table to determine the perimeter of the restricted area, assuming that the source is in the exposed position inside the vehicle. In the case of a minor accident where it can be visually determined that the source is safely stored in its container, no restriction of areas is required.

d. If the survey meter is operable and no radiation hazards exist and the vehicle is movable, continue.

e. In any case immediately after establishing the restricted area, notify your supervisor and the local civil authorities.

3. Source Disconnect

In the event of a source disconnect or loose source in the field, the Radiographer will follow the steps given in paragraph D, Radiation Survey of Working Areas. The Radiation Safety Officer will immediately contact the Radiographer by telephone. If the Radiographer is certain he can safely retrieve the source, he will tell the Radiation Safety Officer of the circumstances and his intentions. The Safety Officer will check the Radiographer's accumulated dose and figure the R/hr output of the isotope at working distance, i.e., the length of the handling tongs, and will tell the Radiographer the amount of time he can spend in attempting to retrieve the source. However, he will not exceed the exposure time limit established by the Safety Officer. The Radiographer will immediately notify the Safety Officer of his success or the progress achieved. The Safety Officer will then decide what further action, if any, will be taken as to the continuation of work.

The following table gives the distance for different source strengths of Iridium 192 and Cobalt 60 at which an area must be roped off to assure a reading of no more than 2 mR/hr. This table is based on the worst condition possible and does not take any shielding into consideration.

CURIES	IRIDIUM 192 DISTANCE FROM SOURCE (FT)	COBALT 60 DISTANCE FROM SOURCE (FT)
100	543	851
95	529	830
90	515	808
85	501	785
80	486	762
75	470	737
70	455	712
65	438	686
60	421	660
55	403	631
50	384	603
45	365	572
40	344	539
35	322	504
30	298	467
25	272	426
20	243	381
15	211	330
10	172	270
5	122	191

C. NOTIFICATION OF INCIDENTS

1. Immediate Notification

Each licensee shall immediately notify the Director of the appropriate NRC Regional Compliance Office as shown in 10 CFR, Part 20, Appendix D, by telephone and telegraph of any incident involving by-product, source or special nuclear material possessed by him and which may have caused or threatens to cause:

a. 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 or 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

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

c. A loss of one working week or more of the operation of any facilties affected; or

d. Damage to property in excess of $200,000.

2. Twenty-Four Hour Notification

Each licensee shall, within 24 hours, notify the Director of the appropriate NRC Regional Compliance Office as shown in 10 CFR, Part 20, Appendix D, by telephone and telegraph of any incident involving licensed material possessed by him and which may have caused or threatens to cause:

a. 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

b. 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 material in Appendix B, Table II; or

c. A loss of one day or more of the operation of any facilities affected; or

d. Damage to property in excess of $2,000.

3. Reports

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

b. Each licensee shall notify the Director of the appropriate NRC Regional Compliance Office as shown in 10 CFR, Part 20, Appendix D, by telephone and telegraph 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.

c. Additional reporting requirements are shown in 10 CFR, Part 20.402.

D. DAILY MAINTENANCE CHECK OF RADIOGRAPHIC DEVICE

The radiographer will perform a daily maintenance check of the exposure device and related radiographic equipment. This inspection will be conducted prior to the use of the equipment on each day and before each shift that radiographic work is to be performed. Report defective equipment to the RSO immediately. Do not attempt to use defective equipment. After determining that the equipment is operative, record the condition of the radiographic equipment.

1. Inspect the remote-control radiographic equipment as follows:

- o Inspect the cables for cuts, breaks, and broken fittings
- o Inspect the crank for damage and loose hardware.
- o Check operation of the control for freedom of drive cable movement.
- o Inspect the guide tube for cuts, crimps, and broken fittings.
- o Survey for radiation levels and record readings. The radiation levels should be about the same as those in previous daily inspections.
- o Check that all safety plugs are in place.
- o Inspect the exposure device for damage to fittings, lock, fasteners, and labels.
- o Check for any impairment of the locking mechanism.
- o Record the results of the daily inspection in the log.

2. Inspect a typical pipeliner device as follows:

a. Source Shield Assembly

Make a radiation survey of exterior surfaces of the source shield assembly. With the center of the survey meter 6 inches (15 cm) from the surface, the radiation levels should not exceed 0.25 milliroentgen per hour per curie. Example: 80 curies x 0.25 = 20 mR/hr

Visually inspect for signs of damage. Check the fastenings on the actuator. Look for missing or loose fasteners.

Check to ensure the safety wiring on the fasteners is intact. Check the nameplate bearing the radiation symbol for presence and legibility. Check that the lock is operable.

b. Control Assembly

Visually check for damage. Test for leaks by turning the control valve to OFF. Pump a vacuum of approximately 15 inches and observe the gauge. The gauge should remain steady. A falling gauge indicates a leak. A leaking control assembly must be repaired.

c. System Check

Conduct the check in an area where the source may be exposed. Position the source shield assembly so that the beam is directed away from you and preferably into a shielding wall or floor. Place a survey meter turned ON adjacent to the projector so you can observe it.

Connect the tube to the source shield assembly.

Lock the projector.

Connect the tube to the correct assembly.

Set the control valve to OFF.

Pump vacuum to approximately 15 inches.

Turn the control to ON. Observe your survey meter. The radiation level should not change. If the radiation level increases, the lock is faulty and must be repaired.

Observe the vacuum gauge. A falling gauge indicates a leak in the control hose or source actuator.

Turn the control to OFF.

Remove the hose from the source shield assembly.

IMPORTANT: Be sure the control valve is turned to OFF. Be sure the hose is removed from the source shield assembly before unlocking.

Unlock the projector.

Replace the hose in the source shield assembly.

Turn the pump control valve to ON. Observe your survey meter. The radiation level should increase. Turn the control valve to OFF. The radiation level should decrease to initial level.

Record the results of the daily inspection in the log.

E. OPERATION OF THE GAMMA INDUSTRIES "CENTURY" MODEL

1. Attach the guide tube, being sure to avoid sharp curving of this cable. Monitor the camera with a survey meter.

2. Set the end of the guide tube in the desired location. Fasten in position by tape, test tube clamp or fasten to a tripod or wooden block.

3. Attach the control cable and extend to its fullest length, with the control handle as far away as possible from the end of the source cable, preferably behind some acceptable type of shielding.

4. Unlock the unit and crank the control cable handle clockwise until it stops. Observe the panoramic control indicator which shows the position of the source to within one inch.

5. After the exposure, source is returned to the camera by turning the handle counter-clockwise until the indicator returns to "0." Monitor the camera and guide tube with a survey meter to make certain the source is inside the unit and is properly shielded.

6. The unit must be locked after each exposure to prevent inadvertent operation.

F. OPERATION OF THE GAMMA INDUSTRIES PIPELINER MODEL 1 CAMERA

1. Check the camera with survey meter. Radiation levels should range between 5 mR/hr and 50 mR/hur at a distance of 6" from the surface.
2. Remove dust cap.
3. Place knurled knob position so that it engages end of shaft.
4. Screw retaining collar over knob.
5. Place camera in position to make exposure.
6. Unlock camera.
7. Expose source by rotating knurled know 180 degrees. The operator "stretches" to keep his body as far away as possible; this is very important.
8. Red indicator pin should now be in view.
9. Source is now exposed. Move as far away as exposure time permits.
10. After prescribed exposure time, turn camera "off" by rotating know 180 degrees opposite to step 7 above. Remember to "stretch" to keep body as far from camera as possible.
11. Red pointer should have disappeared from view.
12. Approach cammera with <u>survey meter</u> in hand.
13. If meter indicates that source is in safe position, lock unit.

NOTE: Source to be removed from camera only by Gamma Industries at direction of RSO.

G. OPERATION OF GAMMA INDUSTRIES GAMMATRON MODEL 20A & 100A

1. Place exposure device in the desired location and lay out the control cable and guide tube as straight as possible. Too many or too tight bends may restrict movement of the drive cable. Monitor camera with a survey meter.

2. Remove safety plug from the lock box.

3. Turn control crank forward (clockwise) and expose about 8" of drive cable.

4. Connect control cable to source pigtail, matching keyway to key on the male and female SAF-T-KEY connector.

5. Crank the control cable back in (counter-clockwise) so that the male thread on the swivel connector can be screwed into the lock box. Attach control cable.

6. Remove safety plug from the outlet nipple on the front of the shield.

7. Connect source guide tube by pulling back the sleeve on the quick disconnect and slide the fitting over the outlet nipple. Slide the sleeve toward the shield and turn it to lock in place.

8. Unlock the unit by turning the handle back (counter-clockwise) which will permit the key to be turned.

9. Crank source out smoothly, slowing the speed of cranking near the end of travel so as not to cause the source to strike the end piece with undue force.

10. Survey to determine that radiation levels are within prescribed limits.

11. At the end of the exposure, retract the source by cranking counter-clockwise. Monitor camera and guide tube with survey meter.

12. SURVEY CAREFULLY TO INSURE THAT THE SOURCE HAS RETURNED TO THE SAFE POSITION. If the survey meter indicates that the source is not in the safe position, INSTITUTE EMERGENCY PROCEDURES AT ONCE.

13. Turn crank back (counter-clockwise) and depress lock plunger.

14. Disconnect control cable and screw safety plug in place.

15. Disconnect source tube and attach safety cap.

16. Return unit to storage area.

E. OPERATION OF AMERSHAM-TECH/OPS MODEL 660

1. Position and secure the source stop of the master source guide tube at the desired location.

2. Position the exposure device at the desired location and connect the extended source tubes as required, laying them as straight as possible. Maintain a bend radius of no less than twenty inches. Monitor exposure device with a calibrated survey meter.

3. Never operate this system with more than three guide tube sections, including the master source guide tube.

4. Remove the safety plug from the exposure device and connect the source guide tube(s) to the exposure device.

5. Determine where the control cables will be located and positioned. Lay out the control cables with a radii of no less than 36 inches.

6. Connect the control cables to the exposure device according to the illustrated sequence in Figures 5.2 through 5.6.

7. Before operation check all connections and bend radii, and check the position of the source shop, which represents the radiographic focal position of the source.

8. Unlock the exposure device lock and rotate the selector ring to the OPERATE position. The source is now free to move.

9. Recheck to be sure that no unauthorized personnel are inside the restricted area.

10. Crank source out smoothly, slowing the speed of cranking near the end of travel so as not to cause the source to strike the end piece of the guide tube with undue force.

11. Survey to determine that radiation levels are within prescribed limits.

12. At the end of the exposure, retract the source by cranking in the RETRACT direction until the crank will no longer move.

13. Approach the exposure device with the survey meter and survey the exposure device on all sides and the entire length of the guide tube(s). SURVEY CAREFULLY TO INSURE THAT THE SOURCE HAS RETURNED TO THE SAFE POSITION. If the survey meter indicates that the source is not in the safe position, INSTITUTE EMERGENCY PROCEDURES AT ONCE.

14. When the source is properly stored in the exposure device, rotate the selector ring from the OPERATE position to the LOCK position and secure it with the exposure device lock.

15. Unlock the exposure device and rotate the selector ring from LOCK to CONNECT. The control unit connector will partially disengage. Refer to illustrated Figures 5.3 and 5.4 to disengage the control cables from the exposure device.

16. Replace the storage cover in the control cables connector and rotate the selector ring to the LOCK position. Remove the key and engage the lock to secure the exposure device. Survey the exposure device on all sides to ensure the source is properly secured.

17. Unscrew the source guide tube and insert the storage plug into the guide tube connector and tighten.

18. Return the exposure device to the storage area.

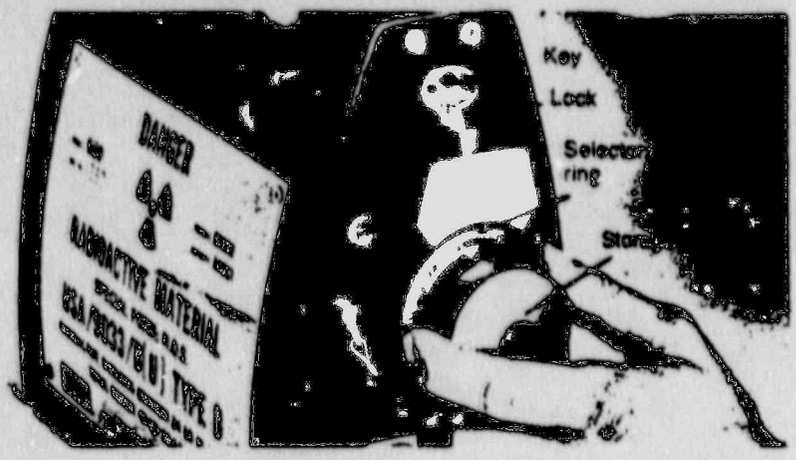


Figure 5.2 Unlock the exposure device with the key provided and turn the selector ring from the LOCK position to the CONNECT position. When the ring is in the CONNECT position, the storage cover will disengage from the exposure device as shown.

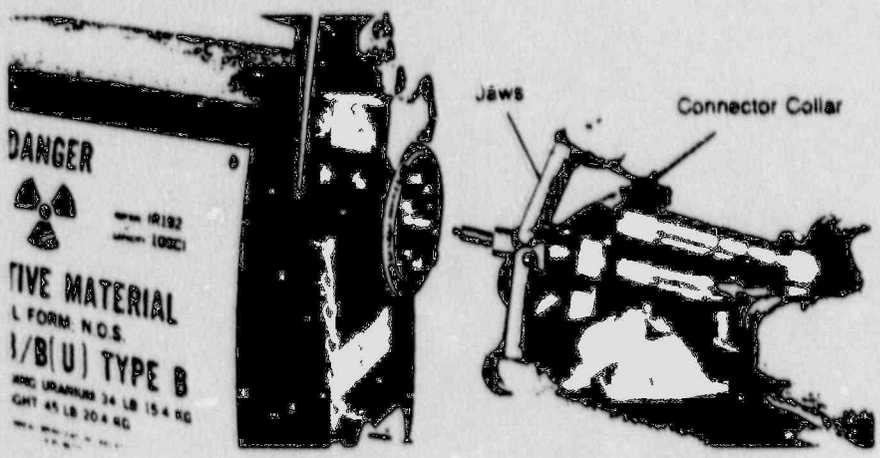


Figure 5.3 Slide the Model 661 connector collar back and open the jaws of the Model 661 connector. This exposes the male portion of the swivel type drive cable connector as shown.

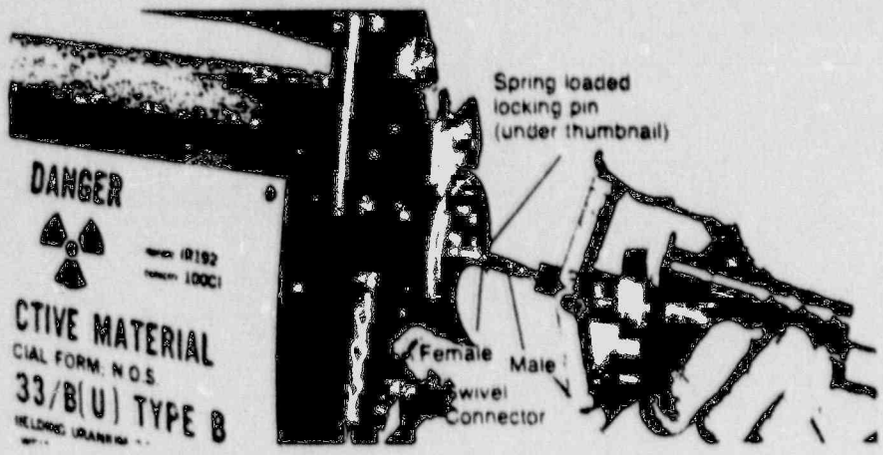


Figure 5.4 Engage the male and female portions of the swivel connector as shown by depressing the spring-loaded locking pin toward the exposure device with the thumbnail. Release the locking pin and test that the connection has been properly made.

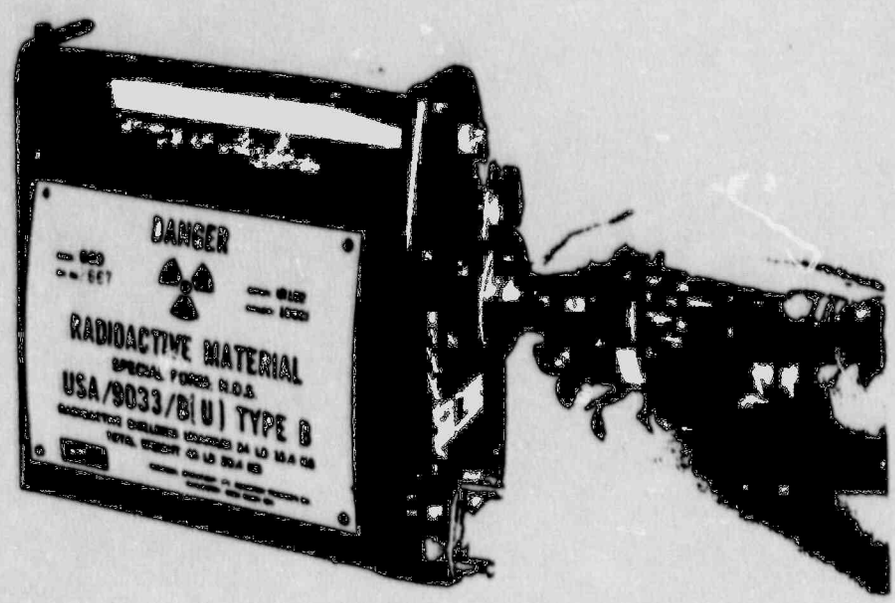


Figure 5.5 Close the jaws of the Model 681 connector over the swivel connector.

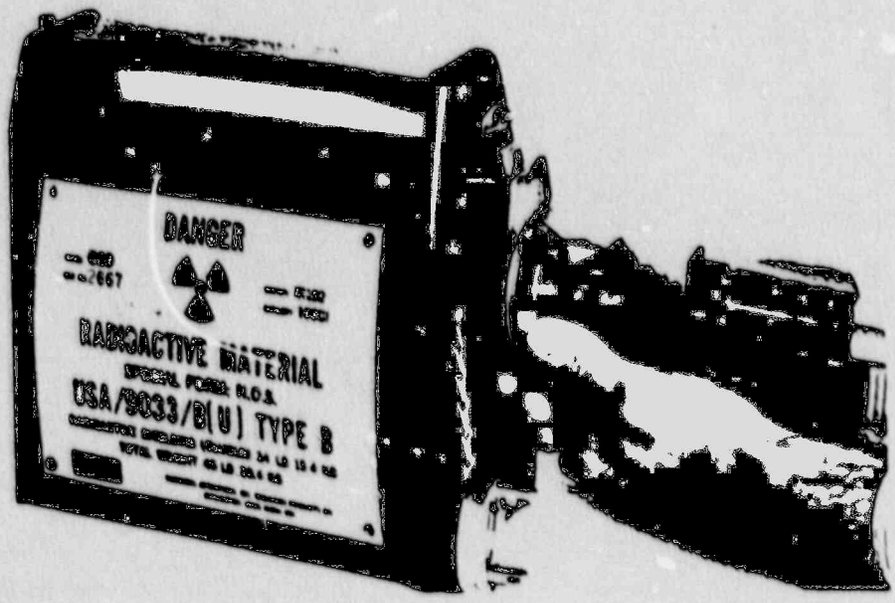


Figure 5.6 Slide the Model 681 connector collar over the connector jaws. Hold the collar flush against the control unit connector and rotate the selector ring from the CONNECT position to the LOCK position. Keep the exposure device locked until operation is ready to start.

I. OPERATION OF AMERSHAM - TECH/OPS MODEL 680

1. Position and secure the source stop of the master source guide tube at the desired location.

2. Position the exposure device of the desired location and connect the extended source tubes as required, laying them as straight as possible, maintain a bend radius of no less than twenty inches. Monitor exposure device with a calibrated survey meter.

3. Never operate this system with more than three guide tube sections, including the master source guide tube.

4. Determine the position of the exposure device allowing for maximum possible operating shielding. Remove the safety plug from the exposure device and connect the source guide tube(s) to the exposure device.

5. Determine where the control cables will be located and positioned. Lay out the control cables with a radii of no less than 36 inches.

6. Connect the control cables to the exposure device according to the illustrated sequence of Section H (operation of Amersham - Tech/Ops Model 660), figures 5.2 through 5.6.

7. Before operation check all connections and bend radii thoroughly, and check the position of the source stop, which represents the radiographic focal position of the source.

8. Unlock the exposure device lock and rotate the selection ring to the OPERATE position. The source is now free to move.

9. Recheck to be sure that no unauthorized personnel are inside the restricted area.

10. Crank source out smoothly, slowing the speed of the cranking near the end of travel so as not to cause the source to strike the end piece of the guide tube with undue force.

11. Survey to determine that radiation levels are within prescribed limits.

12. At the end of the exposure, retract the source by cracking in the RETRACT direction until the crank will no longer move.

13. Approach the exposure device with survey meter and survey the exposure device on all sides and the entire length of the guide tube(s). SURVEY CAREFULLY TO INSURE THAT THE SOURCE HAS BEEN RETURNED TO THE SAFE POSITION. If the survey indicates the source is not in the safe position, INSTITUTE EMERGENCY PROCEDURES AT ONCE.

14. When the source is properly stored in the exposure device, rotate the selector ring from the OPERATE position to the LOCK position and secure it with the exposure device lock.

15. Unlock the exposure device and rotate the selector ring from LOCK to CONNECT. The control unit connector will partially disengage. Refer to the illustrated figures in Section H (Operation of Amersham - Tech/Ops Model 660), figures 5.3 and 5.4 to disengage the control cables from the exposure device.

16. Replace the storage cover on the control cables connector and rotate the selector ring to the LOCK position. Remove the key and engage the lock to secure the exposure device. Survey the exposure device on all sides to ensure the source is properly secured.

17. Unscrew the source guide tube and insert the storage plug into the guide tube connector and tighten.

18. Return the exposure device to a lock storage area.

J. INSPECTION AND MAINTENANCE FOR AMERSHAM-TECH/OPS MODEL 660

The Radiation Safety Officer is required to perform the periodic inspection of exposure devices at intervals not to exceed 90 days or whenever operation of the device appears to be impaired through abuse or wear. However, it should be emphasized that this applies only to the device. DO NOTHING TO THE SOURCE. If the source appears worn or faulty in any way, contact Amersham Inc. In order to perform device inspection and maintenance, proceed as follows:

Control Unit

Drive cable, control housings and source guide tubes - Follow these steps to disassemble to service the drive cable, control housings and source guide tubes.

1. Disconnect the control unit from the exposure device.

2. Turn the hand crank of the control unit in the expose direction until the crank will no longer turn. Do not use force, as this may damage the drive wheel inside the control box. The emergent cable should be cranked into a bucket or other container to keep it clear.

3. Disconnect the control housing from the retract side of the crank and remove the stop spring from the device cable. The drive cable will not pass through the crank.

4. Turn the crank until the drive cable is totally disconnected.

5. Pull the drive cable out through the control cable connector and coil it with a radius of no less than 4 inches.

6. Remove the control cable connector and connector plug from the control housings, and disconnect the other control housing from the crank.

7. Clean the drive cable with chlorothene and flush the control housings and source guide tubes.

8. Using compressed dry air (15 psi maximum), thoroughly dry the drive cable, control housing, and guide tubes, any remaining solvent can cause permanent damage.

9. Check the source guide tubes for binding by holding them vertical and dropping a dummy source through them. Wipe the guide tubes and control housings with a cloth soaked in chlorothene and flex them to check for internal damage.

Damage is evidenced by a crunching feeling when the housing or tube is bent. While doing this, feel for dents. Cut, flatten or blunt control housings on guide tubes should be repaired or replaced.

10. Using a Model 550 no-go gauge, check the male connection of the drive cable. If the ball of the connector fits through the hole of the gauge or the ball shank fits into the slot in the gauge, the connector is worn and the cable must be replaced.

11. Lightly grease the cable using a multi-temperature grease.

12. Attach the control housing to the exposure side of the control box and to the connector.

13. Feed the drive cable into the housing as far as it will go. As the drive cable is being fed in, feel the resistance to the drive cable to detect any binding of the cable. This indicates a dent in the control housing which should be repaired or replaced.

14. Turn the hand crank until the drive cable is protruding, and screw the stop spring to the end of the drive cable.

15. Connect the other control housing to the crank and to the connector plug.

16. Turn the crank fully to the retract position and watch for any binding of the drive cable to check the other section of the control housing for dents. Repair or replace the control housing, if necessary.

17. Place plastic dust caps on the ends of the source guide tubes and control cable connector to eliminate dust accumulation.

Exposure Device

To service the exposure device, remove the source following the source changing procedures of Section R. Before removing source, check the female device cable connector of the source with the no-go gauge. If the connector is worn, replace the source connector as soon as possible. After the source has been removed, service the exposure device by performing the following steps.

1. Remove the danger tag from the bottom of the rear plate and remove the rear plate by unscrewing the six phillips head screws securing the rear plate to the exposure device body.

2. Unlock the connector lock and then remove the lock assembly and control unit connection assembly by unscrewing the six socket head screws securing them to the rear plate.

3. Disassemble the control unit connector assembly, see figure 7.5 for order of removal.

4. Disassemble the lock assembly, see figure 7.6, Order of Removal. Remove the lock from the lock retainer by unscrewing the screws and turning the key 90°.

5. Remove the front end plate from the exposure device, and remove guide tube connection and retaining ring with pliers.

6. Clean all parts in chlorothene and flush the service tube with solvent. Dry the parts and the source tube thoroughly using dry compressed air.

7. Inspect all parts for damage or excessive wear, and replace if necessary.

8. Lightly grease all moving parts at their contact surface using multi-temperature grease.

9. Replace front end plate, and secure with the proper screws.

10. Replace the lock by placing the returned springs and spring guides into the lock, depressing the internal plunger, inserting the lock into the lock returner and securing the lock with the proper screws.

11. Secure the lock assembly to the rear plate with the proper screws.

12. Reassemble the control unit connection assembly.

13. Connect the jumper to the short length drive cable and insert the cable through the rear end plate and control unit connector assembly.

14. Insert the U-tool into the control unit connection assembly and check the operation by turning the selection ring from OPERATE to CONNECT several times.

15. Secure the rear end plate to the exposure device and handle using the proper screws and replace the protective plate over the bottom two near plate screws using pop rivets.

16. Reload source into the exposure device.

17. Survey the exposure device on all sides to ensure that radiation levels do not exceed 200 mR/hr at the surface. and 10 mR/hr at 3 feet from the surface.

K. INSPECTION AND MAINTENANCE FOR AMERSHAM - TECH/OPS MODEL 680

The Radiation Safety Officer is required to perform the periodic inspection of exposure devices at intervals not to exceed 90 days or whenever operation of the device appears to be impaired through abuse or wear. However, it should be emphasized that this applies only to the device. Do nothing to the source. If the source appears worn or faulty in any way, contact Amersham Inc. In order to perform device inspection and maintenance, proceed as follows:

Control Unit

Drive cable, control housings and source guide tubes - Follow these steps to disassemble to service the drive cable, control housings and source guide tubes.

1. Disconnect the control unit from the exposure device.

2. Turn the hand crank of the control unit in the expose direction until the crank will no longer turn. Do not use force, as this may damage the drive wheel inside the control box. The emergent cable should be cranked into a bucket or other container to keep it clear.

3. Disconnect the control housing from the retract side of the crank and remove the stop spring from the device cable. The drive cable will not pass through the crank.

4. Turn the crank until the drive cable is totally disconnected.

5. Pull the drive cable out through the control cable connector and coil it with a radius of no less than 4 inches.

6. Remove the control cable connector and a connector plug from the control housings, and disconnect the other control housing from the crank.

7. Clean the drive cable with chlorothene and flush the control housings and source guide tubes.

8. Using compressed dry air (15 psi maximum), thoroughly dry the drive cable, control housing, and guide tubes, any remaining solvent can cause permanent damage.

9. Check the source guide tubes for binding by holding them vertical and dropping a dummy source through them. Wipe the guide tubes and control housings with a cloth soaked in chlorothene and flex them to check for internal damage.

Damage is evidenced by a crunching feeling when the housing or tube is bent. While doing this, feel for dents. Cut, flatten or blunt control housings on guide tubes should be repaired or replaced.

10. Using a Model 550 no-go gauge, check the male connection of the drive cable. If the ball of the connector fits through the hole of the gauge or the ball shank fits into the slot in the gauge, the connector is worn and the cable must be replaced.

11. Lightly grease the cable using a multi-temperature grease.

12. Attach the control housing to the exposure side of the control box and to the connector.

13. Feed the drive cable into the housing as far as it will go. As the drive cable is being fed in, feel the resistance to the drive cable to detect any binding of the cable. This indicates a dent in the control housing which should be repaired or replaced.

14. Turn the hand crank until the drive cable is protruding, and screw the stop spring to the end of the drive cable.

15. Connect the other control housing to the crank and to the connector plug.

16. Turn the crank fully to the retract position and watch for any binding of the drive cable to check the other section of the control housing for dents. Repair or replace the control housing, if necessary.

17. Place plastic dust caps on the ends of the source guide tubes and control cable connector to eliminate dust accumulation.

Exposure Device

To service the exposure device, remove the source following the source changing procedures of Section R. Before removing source, check the female device cable connector of the source with the no-go gauge. If the connector is worn, replace the source connector as soon as possible. After the source has been removed, service the exposure device by performing the following steps.

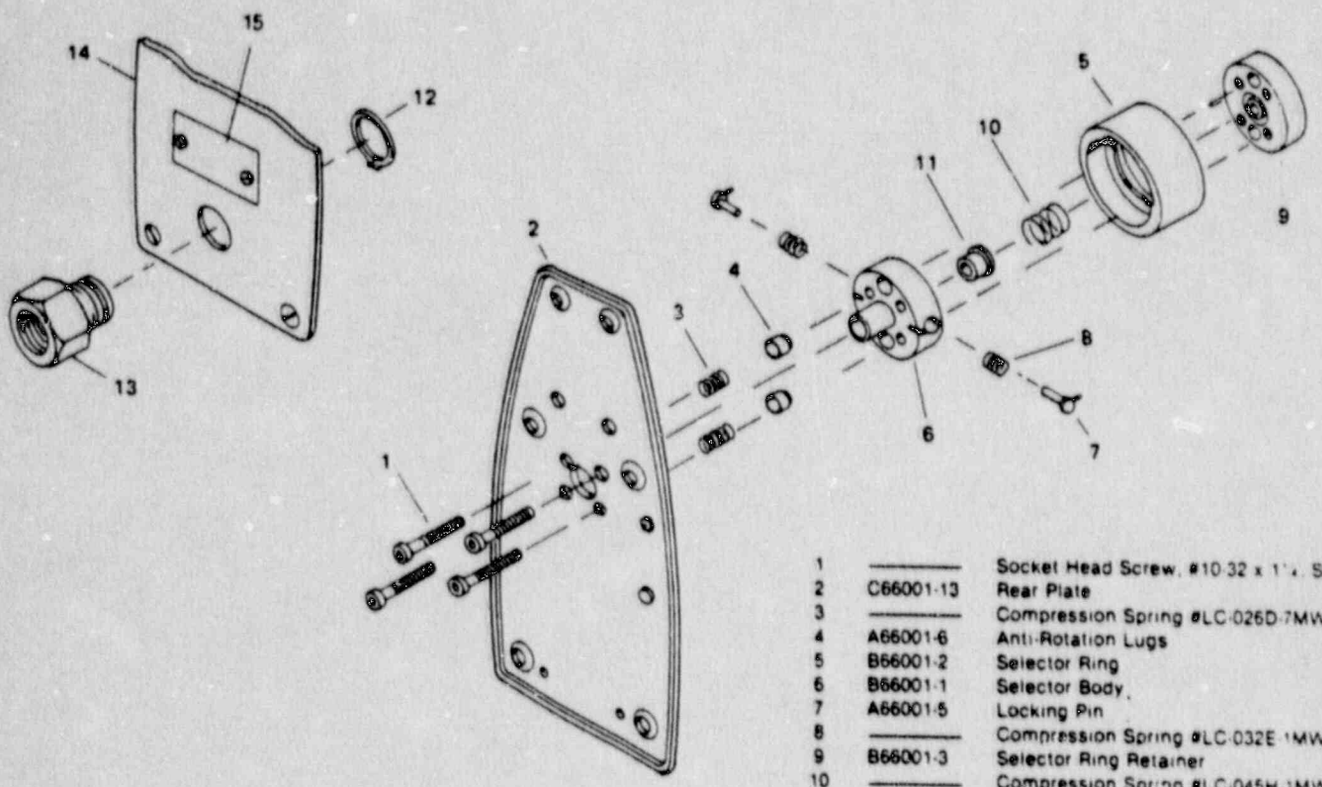
1. Remove the danger tag from the bottom of the rear plate and remove the rear plate by unscrewing the six phillips head screws securing the rear plate to the exposure device body

2. Unlock the connector lock and then remove the lock assembly and control unit connection assembly by unscrewing the six socket head screws securing them to the rear plate.

3. Disassemble the control unit connector assembly, see figure 7.5 for order of removal.

Exposure Device

The source shield portion of the exposure device is not repairable in the field. Seal wires have been attached to prevent opening the shield which could result in a serious radiation overexposure.



1	————	Socket Head Screw, #10-32 x 1¼, Stainless
2	C66001-13	Rear Plate
3	————	Compression Spring #LC-026D-7MW, Lee
4	A66001-6	Anti-Rotation Lugs
5	B66001-2	Selector Ring
6	B66001-1	Selector Body
7	A66001-5	Locking Pin
8	————	Compression Spring #LC-032E-1MW, Lee
9	B66001-3	Selector Ring Retainer
10	————	Compression Spring #LC-045H-1MW, Lee
11	A66001-4	Sleeve
12	————	Heavy Duty Retaining Ring, Tru-Arc #5160-98
13	B65501-8	Connector
14	C66001-14	Front Plate
15	————	Source Identification Plate

Figure 7.5 Rear End Plate and Control Unit Connector—Exploded View

1	————	Socket Head Screw, #10-32 x 1¼, Stainless
2	C66001-13	Rear Plate
3	B66001-12	Lock Retainer
4	————	Screw (supplied as part of item 5)
5	————	Lock
6	A66u01-11	Key

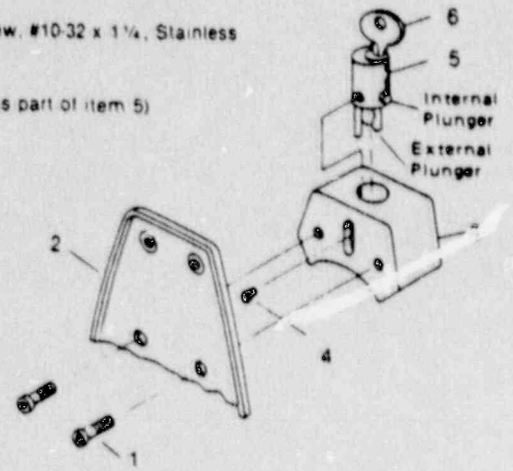


Figure 7.6 Lock Assembly—Exploded View

L. PERIODIC INSPECTION AND MAINTENANCE FOR GAMMA INDUSTRIES CENTURY, GAMMA INDUSTRIES GAMMATRON

The Radiation Safety Officer is required to perform the periodic inspection of exposure devices at intervals not to exceed 90 days or whenever operation of the device appears to be impaired through abuse or wear. However, it should be emphasized that this applies only to the device. DO NOTHING TO THE SOURCE. If the source appears worn or faulty in any way, contact Gamma Industries. In order to perform device inspection and maintenance, proceed as follows:

1. Remove safety cap in lock box and inspect source conector. The holding pin should have a true 90-degree elbow, it should be straight and parallel with axis of source connector and the key on apex of elbow should not be worn excessively. Check flexible cable at connector for straightness.

   Maintenance: If the elbow is not bent out of line, the mating connector should then be connected to the source and tested by pulling straight back on cable applying about 30 to 40 pounds pressure.

2. The lock plunger should be inspected and checked for ease of operation. Foreign matter may at times foul the plunger and make it inoperative. The lock plunger may not retract to its fullest extent which is 1/2 inch. This would prevent free travel of the source in and out of the lock box.

   Maintenance: The lock plunger may be removed by removing the two 8-32 set screws in the lock box. Wash lock in solvent to remove dirt or other foreign matter. Lock may also be cleaned and lubricated by spraying a lubricant (such as WD-40 into the lock).

3. Inspect the source outlet nipple by first removing safety plug. The outlet nipple should be round and smooth so that it will match with the ID of the source tube.

   Maintenance: If the outlet nipple should be out-of-round it can sometimes be straightened by using a punch or round bar on the inside of the outlet. If it cannot be straightened or if the nipple has been broken by dropping the unit, it must be replaced. This replacement can be done in the field shop, or returned to Gamma Industries.

4. Inspect labeling on exposure device. The warning signs and source identification tags should be distinct and legible.

5. Inspect source tubes for damage such as crimps, foreign matter, ease of connecting, and disconnecting from exposure device.

   Maintenance: Crimps, kinks, and other damaged places may be cut out and connectors placed on ends so that tube is not shortened excessively. The quick disconnect coupling that connects to outlet nipple of exposure device may be removed with heat and replaced. Foreign matter may be washed from tube with solvent and blown with compressed air.

6. Inspect source connector on drive cable. The hole should be 7/64" in diameter when new. This hole should show some wear after much use but should not be out-of-round to the extent that it will disconnect from the mating piece other than in the correct position. It should not be loose on the drive cable. The portion of the connector with the connector hole should not be bent, but should be straight and parallel with body of connector.

   Maintenance: This worn connector may be replaced by one of two methods:

   a. Send back to Gamma Industries to have new connector replacement.

   b. Order new core with connector attached.

7. Inspect remainder of drive cable for wear, rusty sections, causing cable to become stiff and non-flexing, kinks, or other damaging conditions that would prevent cable from running on gear in the gear box housing.

   Maintenance: The drive cable should be cleaned with a solvent such as varsol, diesel fuel or some other solvent that will not dry out. This is done to remove sand, dust and other foreign matter that will cause abrasions in the exposure device and gear box drive mechanism. Drive cable that has become rusty and non-flexible should be replaced. Failure to replace cable may cause controls to become stiff, hard to operate, wear excessively, and possibly break. The cable would usually break when the source is exposed. Lubrication of the drive cable is important. In areas where there is a problem with sand or other abrasive material, dry powdered graphite is excellent. Graphite should not be used continually, however, since the graphite will tend to pack in the gear box and cause excessive wear to the gear housing and to the gear. Where the control cables can be kept reasonably clean, a light oil will be adequate.

8. Inspection of control assembly. This assembly consists of the gear box assembly and the crank handle. The bronze bushings in the gear housing and the plate are the most likely places to find wear. When these bushings are worn they tend to permit the gear to wobble and eventually wear out. Usually (due to some build-up either on the drive cable or the gear teeth) there will be some wear around the inner circumference of the housing. This will permit the drive cable to slip on the gear and prevent source from moving properly through the exposure device.

   Maintenance: It is suggested that if powdered graphite is used as a lubricant, the gear box be cleaned with compressed air occasionally so as to remove any packed graphite in the gear mechanism. The application of some type light oil on bronze bushings will help prevent excessive wear.

9. Inspect drive cable housing or conduit. This conduit can be damaged by dropping it across a hot weld, severe kinking, or by dropping some object on the conduit. Any of these can prevent the drive cable from moving freely. The conduit at the end connections may become damaged from flexing while being assembled or disassembled.

   Maintenance: In any case where the inner liner has been damaged, the conduit must be replaced. When the outer covering has been damaged, waterproof tape should be wrapped around the break to prevent the entrance of water or other corrosive substances. If the extreme ends of the conduit are damaged, these can be replaced with new pieces by returning the conduit to Gamma Industries.

M. PERIODIC INSPECTION AND MAINTENANCE FOR THE GAMMA INDUSTRIES PIPELINER

The Radiation Safety Officer is required to perform the inspection of exposure devices at intervals not to exceed 90 days or whenever operation of the device appears to be impaired through abuse or wear. It should be emphasized that this applies only to the device. NO ATTEMPT should be made to visually inspect or remove the SOURCE. Inspection and replacement of sources must be performed by skilled personnel at Gamma Industries in Baton Rouge, Louisiana.

Since the PIPELINER must be returned to Gamma Industries for source replacement, a complete inspection and all necessary repair work will be accomplished upon receipt by the manufacturer. The following safety checklist may be applied by field personnel:

1. The lock plunger should be inspected and checked for ease of operation. Foreign matter may at times foul the plunger and make it inoperative. The lock plunger may not retract to its fullest extent which is 1/2 inch.

   Maintenance: The lock plunger may be removed by removing the two 8-32 screws in the lock box. Wash lock in solvent to remove dirt or other foreign matter. Lock may also be cleaned and lubricated by spraying a lubricant (such as WD-40) into the lock.

2. Inspect labeling on exposure device. The warning signs and source identification tags should be distinct and legible.

3. Should significant resistance be encountered in turning the rotor, the unit should be returned to Gamma Industries for inspection and repair.

N. WIPE TEST PROCEDURE FOR GAMMA INDUSTRIES GAMMATRON MODEL 20A AND 100A.

1. Using a survey meter, ascertain that the source is in a safe position and camera is locked.

2. The Radiographer will use a Gamma Industries Kowipe Leak Test Kit.

3. From the wipe test kit, dissolve the contents of the detergent packet in a small of volume of water. Using the swab from the left packet, dampened with the detergent solution, thoroughly wipe the inner walls of the cable near the open end. Replace the swab in the left packet. Using the dry swab from the right packet, wipe the same areas again. Replace this swab in the right packet. A Gamma Industries Kowipe Leak Test Kit will be used.

4. After wiping the cable, connect the cable to the "camera," and prepare the wipe fit for mailing back to Gamma Industries, Inc.

5. Using a survey meter, determine if there is any radiation being emitted from the wipe test kit.

   a. If there is no detectable radiation being emitted, the wipe test should immediately be mailed back to Gamma Industries for testing and reporting results to you.

   b. If there is detectable radiation being emitted, DO NOT MAIL the wipe test kit but immediately inform the Radiation Safety Officer of this condition.

NOTE: The wipe test procedure will be performed only by a Radiographer.

0. WIPE TEST PROCEDURE FOR GAMMA INDUSTRIES PIPELINE MODEL 1

1. The Radiographer will perform the wipe test using a Gamma Industries Kowipe Leak Test Kit.

2. Using a survey meter, ascertain that the source is in a safe position.

3. Be sure that the unit is locked and secure.

4. From the wipe test kit, dissolve the contents of the detergent packet in a small volume of water. Using the swab from the left packet, dampened with the detergent solution, thoroughly wipe any surfaces of the device that are apt to be contaminated as a result of a leaking source. Be sure to wipe the joint where the face plate bolts to the bottom of the device. Replace the swab in the left packet. Using the dry swab from the right packet, wipe the same areas again. Replace the swab in the right packet.

5. Using a survey meter, determine if there is any radiation being emitted from the swabs.

   a. If there is no detectable radiation being emitted, the wipe test kit should immediately be mailed back to Gamma Industries, Inc. for testing and reporting results to you.

   b. If there is detectable radiation being emitted, DO NOT MAIL the wipe test kit but inform the Radiation Safety Officer of this condition.

NOTE: The wipe test procedure will be performed only by a Radiographer.

P. WIPE TEST FOR AMERSHAM-TECH/OPS 660 AND 680

1. Using a survey meter, ascertain that the source is in a safe position and the exposure device is locked.

2. Amersham-Tech/Ops leak test kit will be used.

3. Moisten the wipe test swab with water.

4. Wipe the inside of the S-tube and the female connector assembly with the wipe test swab.

5. Place the wipe test swab in the plastic envelope.

6. Using a survey meter, determine if there is any radiation being emitted from the plastic envelope.

   A. If no detectable radiation is being emitted, the wipe test plastic envelope should be mailed immediately to Amersham-Tech/Ops.
   B. If radiation levels are in a detectable range, DO NOT mail the wipe test envelope and DO NOT USE the exposure device but notify the Radiation Safety Officer immediately of the condition found.

7. The wipe test procedure will be performed by a radiographer only.

IMPORTANT - READ CAREFULLY BEFORE CHANGING SOURCE

SOURCE CHANGING INSTRUCTIONS

FOR C-10 SHIPPING CONTAINER

Single Source Configuration

Attached is a cross-sectional view of the shipping container used for transporting your pigtail source. The container has two lock boxes — one on each side. The upper lock box is labeled "NEW SOURCE" and the upper tube contains the new source. The lower lock box and tube will be used to return the decayed source to Gamma Industries.

The following procedure should always be followed in the source changing operation:

ALWAYS HAVE A PROPERLY OPERATING SURVEY METER AT HAND WHEN CHANGING SOURCES!

1. Survey the C-10 shipping container with meter. The radiation intensity should not exceed 10 mR/hr at 1 meter from any surface of the C-10.

2. Open the lower lock of the C-10 shipping container. Remove the safety plug.

3. Connect one end of short exchange tube (provided in the shipping barrel) to the lower lock box of the C-10 shipping container. Attach the other end of the short exchange tube to your camera. See Figure 1 below:

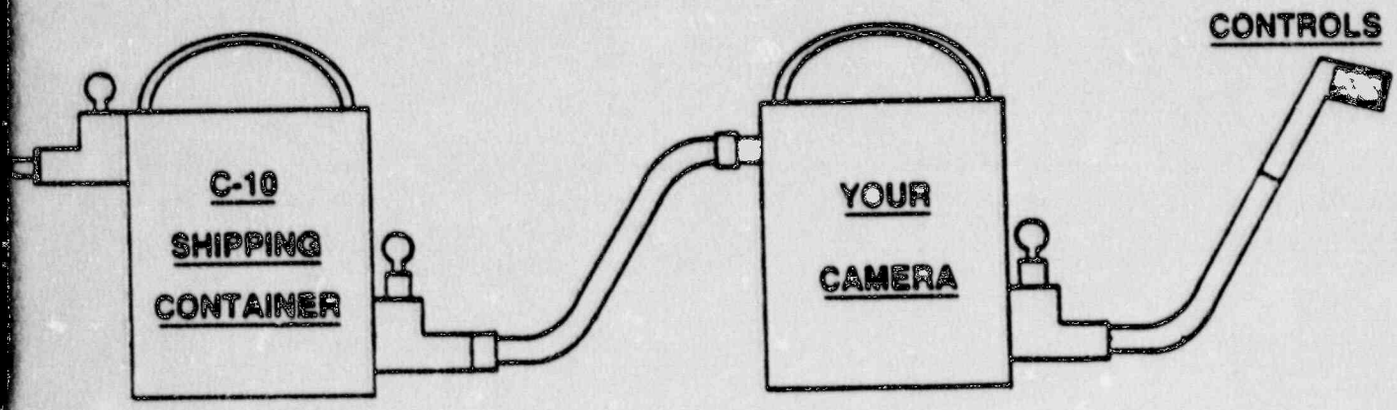


FIGURE 1

4. Crank your old source into the C-10 shipping container until it reaches a definite stop.

5. Survey to assure that the old source has reached a safe position.

6. Lock the lower lock of the C-10 shipping container onto the old pigtail locking ball. You must be aware that the source could be removed from the open end of the lock box if the lower lock is not locked.

7. Remove the short exchange tube from the C-10 shipping container. Disconnect the control cable from the old pigtail. (Attempt to move the pigtail into and out of the C-10 shipping container to assure the lock is depressed upon the pigtail locking ball. If the pigtail can be moved, then open the lower lock, carefully push the pigtail into the container, and lock the lock upon the pigtail locking ball. This will assure that the old source will remain properly locked and shielded during the return shipment.

8. Remove the source protector cap from the upper lock box and attach the source protector cap over the old source pigtail in the lower lock box.

9. Attach the control cable to the new pigtail which is in the upper lock box.

10. Attach short exchange tube to the C-10 shipping container upper lock box. See Figure 2 below:

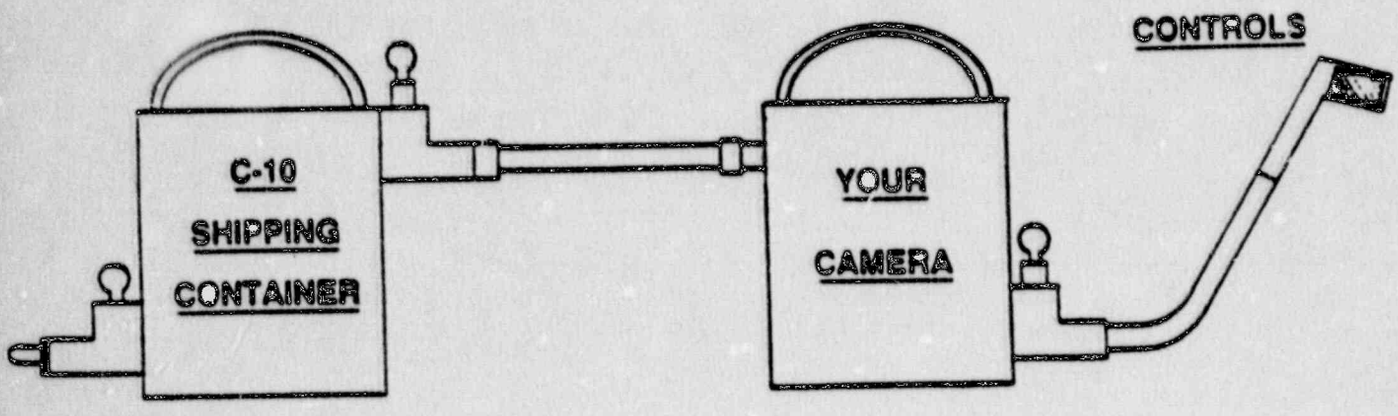


Figure 2

11. Unlock the upper lock from the new source.

12. Standing as far away as possible, crank the new source from the C-10 shipping container into your camera.

13. Survey.

14. Lock your camera lock.

15. Remove the short exchange tube from your camera. Remove the short exchange tube from the C-10 shipping container.

16. Insert the safety plug into the upper tube of the C-10 shipping container. Lock the upper lock on the C-10 shipping container.

17. Survey.

18. Place the C-10 into the barrel in the same orientation which it was received. Place the short exchange tube into the barrel. Place the top on the barrel and secure with the locking ring.

19. Insert a safety seal into the barrel lock ring.

20. Survey. (The radiation intensity should not exceed 200 mR/hr at any barrel surface or 10 mR/hr at one meter from any barrel surface.)

END OF SOURCE INTERCHANGE INSTRUCTIONS

R. INSPECTION AND OPERATION OF SOURCE CHANGERS FOR AMERSHAM MODEL 660 AND 680

1. Survey the source changer to ensure the source is in the proper storage position.

2. Position the source changer and the exposure device close together so that one section of source guide tube will connect them with no sharp turns or bends.

3. Remove the storage plug from the exposure device, and attach the source guide tube. Remove the source charger cover and attach the other end of the tube to the empty chamber of the source changer.

4. Attach the control unit to the exposure device.

5. Crank source rapidly from the exposure device to the source changer.

6. Approach the source changer and source guide tube with a survey meter to ensure that the source is fully within the safe position of the source changer.

7. Open the source guides and disconnect the device cables from the source assembly by moving the lock pin down and sliding the drive cable connector ball out through the keyway.

8. Disconnect the source guide tube from the changer. If a replacement source is to be installed in the exposure device, connect the source guide tube to the fitting above the chamber containing the new source and couple the drive cable to the new source.
    a. Removal of the source from service. Connect the drive cable to the jumper that is clipped inside the storage cover of the exposure device.

9. Return to the controls and crank the new source (or jumper) into the exposure device.

10. Survey the exposure device to ensure that the process has been properly completed. Rotate the selection ring to the lock position. Survey the source guide tube and source changer to verify that the source has been correctly transferred.

11. Secure the source in the service changer in accordance with the appropriate source charger instruction manual.

12. Disconnect the control unit and source guide tube from the exposure device, disassemble and disconnect the source guide tube from the source changer.

13. Remove the source identification plate from the exposure device and attach it with seal wire to the source hold down cap.

14. If the exposure device contains a source, affix the identification plate of the new source to the exposure device, if not, attach an empty tag to the handle of the exposure device.

15. Return the source changer to Amersham-Tech/Ops with the proper shipping labels attached.

SECTION VII

NRC OFFICES

SECTION VIII

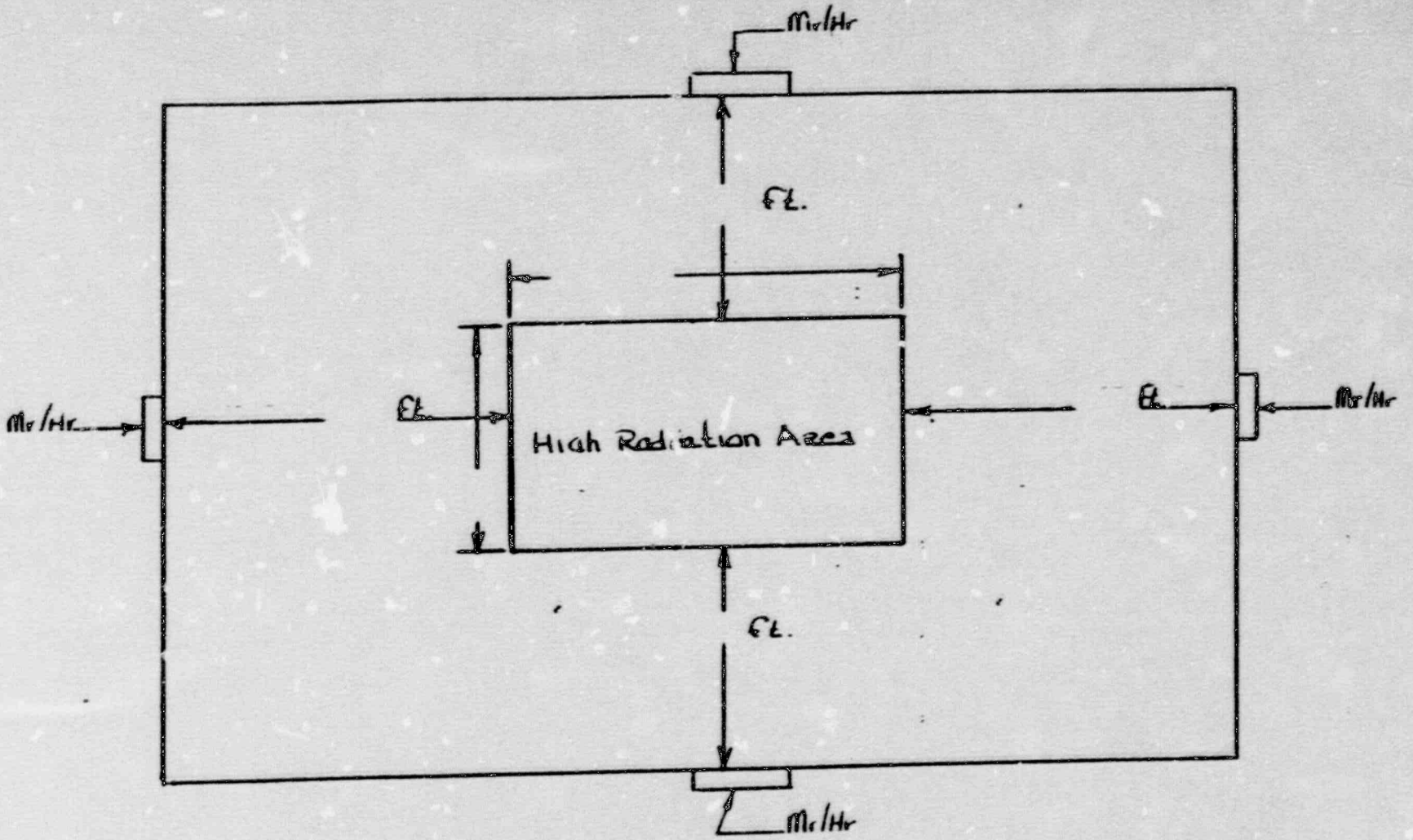
SIGNS

[ORIGINAL SIGNS TO BE INSERTED HERE]

SECTION IX

FORMS

Radiation Survey Diagram



Exposure Time:											
No of Exposures:											

Radiographer: _____, Source: _____, Curies: _____

Location: _____, Survey Meters used: _____ and _____.

JOB NO. _____ SHEET _____ OF _____

DATE _____ CK _____ DATE _____ JOB NAME _____

AW ENGINEERING

LAW ENGINEERING

Monthly Report of Radiation Surveys

ate	Source	No. Curies	Job & Location	Safe Distance	m[illegible]/Hr	Technician

A copy of this report is to be kept in file at the originating office

Law Engineering

LAW ENGINEERING

RADIOACTIVE MATERIAL TRANSPORTATION FORM

RADIOACTIVE MATERIAL	FORM	ACTIVITY	CATEGORY	PACKAGE ID

From: _____ To: _____

_____ _____

_____ _____

VEHICLE SURFACE SURVEYS

DEPARTURE _____MR/HR RETURN _____MR/HR

EMERGENCY PROCEDURES:

Vehicular Accident:

a) In the event of a vehicular accident involving product material while traveling to an exposure site, a restricted area must be set up and posted.

b) If survey meter is operable, use it to establish the perimeter of the restricted area.

c) If the survey meter is inoperable, use calculations to determine the perimeter of the restricted area, assuming that the source is in the exposed position inside the vehicle. In the case of a minor accident where it can be visually determined that the source is safely stored in its container, no restriction of areas is required.

d) If the survey meter is operable and no radiation hazards exist and the vehicle is movable, continue.

e) In any case immediately after establishing the restricted area, notify your RSO:

VA.RSO: Grant Lilley	Home	703/791-6569
	Office	703/968-4700
MAT. MGR/WASH.: Chris Hodges	Home	703/754-2002
	Office	703/968-4700
WASH. BRNCH MGR: William Mosher	Home	301/997-1564
	Office	703/968-4700
B-P MAT. LIC. COORD.: G. Miller	Home	404/979-5347
	Office	404/396-8000

_____

SIGNATURE

FIELD RADIOGRAPHY

Internal Inspection Checklist

Radiographic Location _____ Date_____ Time_____

Radiographer _____ Inspector _____

Radioisotope _____ Curies _____ Serial No. _____

Projector Serial No. _____ Projector Model No. _____

Survey Meter Model No. _____ Serial No. _____

Calibration Due Date _____

	YES	NO
1. Was the radiographer wearing a film badge and dosimeter?	___	___
2. Were other individuals working within the restricted area wearing film badges and dosimeters?	___	___
3. Was the restricted area posted with "CAUTION (or DANGER) RADIATION AREA" signs?	___	___
4. Was the restricted area properly controlled to prevent unauthorized entry?	___	___
5. Was the high radiation area posted with "CAUTION (or DANGER) HIGH RADIATION AREA" signs?	___	___
6. Did the radiographer have a calibrated and properly operating survey meter?	___	___
7. Was the utilization log properly filled out?	___	___
8. Did the radiographer have sufficient knowledge of safety rules? (Ascertained by oral questions.)	___	___
9. Was the radiographer working with defective equipment?	___	___
10. Did the radiographer properly survey the source projector and source tube and take a radiation reading 1 foot (0.3 m) in front of the source following the radiographic exposure?	___	___

Internal Inspection Checklist

	YES	NO
11. Were radioactive isotopes stored properly and kept locked to prevent unauthorized removal?	___	___
12. Was the storage area posted with "CAUTION (or DANGER) RADIOACTIVE MATERIAL" signs?	___	___
13. Did the radiographer possess a copy of the applicant's operating and emergency procedures and, as applicable, State or NRC rules and regulations for protection against radiation?	___	___
14. Were there any items of noncompliance other than those listed on this form? (If any, explain in remarks.)	___	___

Remarks _____

_____

_____

_____

_____

_____

Form NRC-4
(5-72)
10 CFR 20

U. S. NUCLEAR REGULATORY COMMISSION

Approved by GAO
B-180225 (R0043)
Expires - 6-30-77

OCCUPATIONAL EXTERNAL RADIATION EXPOSURE HISTORY

See Instructions on the Back

IDENTIFICATION

1. NAME (PRINT – LAST, FIRST, AND MIDDLE)	2. SOCIAL SECURITY NO.
3. DATE OF BIRTH (MONTH, DAY, YEAR)	4. AGE IN FULL YEARS (N)

OCCUPATIONAL EXPOSURE – PREVIOUS HISTORY

5. PREVIOUS EMPLOYMENTS INVOLVING RADIATION EXPOSURE–LIST NAME AND ADDRESS OF EMPLOYER	6. DATES OF EMPLOYMENT (FROM–TO)	7. PERIODS OF EXPOSURE	8. WHOLE BODY (REM)	9. RECORD OR CALCULATED (INSERT ONE)

10. REMARKS	11. ACCUMULATED OCCUPATIONAL DOSE – TOTAL	

13. CALCULATIONS – PERMISSIBLE DOSE WHOLE BODY:

(A) PERMISSIBLE ACCUMULATED DOSE = 5(N–18) = _____ REM

(B) TOTAL EXPOSURE TO DATE (FROM ITEM 11) = _____ REM

(C) UNUSED PART OF PERMISSIBLE ACCUMULATED DOSE (A–B) = _____ REM

12. CERTIFICATION: I CERTIFY THAT THE EXPOSURE HISTORY LISTED IN COLUMNS 5, 6, AND 7 IS CORRECT AND COMPLETE TO THE BEST OF MY KNOWLEDGE AND BELIEF.

EMPLOYEE'S SIGNATURE DATE

14. NAME OF LICENSEE

INSTRUCTIONS FOR PREPARATION OF NRC FORM 4

This form or a clear and legible record containing all the information required on this form must be prepared by each licensee of the Nuclear Regulatory Commission who, pursuant to Section 20.101, proposes to expose an individual to a radiation dose in excess of the amounts specified in Paragraph 20.101(a) of the regulations in Part 20, "Standards for Protection Against Radiation," 10 CFR. The requirement for completion of this form is contained in Section 20.102 of that regulation. The information contained in this form is used for estimating the external accumulated occupational dose of the individual for whom the form is completed. A separate Form NRC-4 shall be completed for each individual to be exposed to a radiation dose in excess of the limits specified in Paragraph 20.101(a) of Part 20 of the Commission's regulations.* Listed below by item are instructions and additional information directly pertinent to completing this form:

Identification

Item 1. Self-explanatory.

Item 2. Self-explanatory except that, if individual has no social security number, the word "none" shall be inserted.

Item 3. Self-explanatory.

Item 4. Enter the age in full years. This is called "N" when used in calculating the Permissible Dose. N is equal to the number of years of age of the individual on his last birthday.

Occupational Exposure

Item 5. List the name and address of each previous employer and the address of employment. Start with the most recent employer and work back.

Include only those periods of employment since the eighteenth birthday involving occupational exposure to radiation. For periods of self-employment, insert the word "self-employed."

Item 6. Give the dates of each employment listed in Item 5.

Item 7. List periods during which occupational exposure to radiation occurred.

Item 8. List the dose recorded for each period of exposure from the records of previous occupational exposure of the individual as calculated under Section 20.102. Dose is to be given in rem.

"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.

Item 9. After each entry in Item 8 indicate in Item 9 whether dose is obtained from records or calculated in accordance with Section 20.102.

Item 10. Self-explanatory.

Total Accumulated Occupational Dose (Whole Body)

Item 11. The total for the whole body is obtained by summation of all values in Item 8.

Certification

Item 12. Upon completion of the report, the employer must certify that the information in Columns 5 through 7 is accurate and complete to the best of his knowledge. The date is the date of his signature.

Calculations

Item 13. The lifetime accumulated occupational dose for each individual and the permissible dose under Paragraph 20.101(b) are obtained by carrying out the following steps: The value for N should be taken from Item 4. Subtract 18 from N and multiply the difference by 5 rem. (For example, John Smith, age 32; N = 32, PAD = 5(32-18) = 70 rem.) Enter total exposure to date from Item 11. Subtract (b) from (a) and enter the difference under (c). The value in (c) represents the unused part of the permissible accumulated dose. This value for permissible dose is to be carried forward to Form NRC-5, "Current Occupational External Radiation Exposure (Whole Body)."

Item 14. Self-explanatory.

*This form requires the signature of the employee concerned.

PRIVACY ACT STATEMENT

Pursuant to 5 U.S.C. 552a(e) (3), enacted into law by section 3 of the Privacy Act of 1974 (Public Law 93-579), the following statement is furnished to individuals who supply information to the Nuclear Regulatory Commission on Form NRC-4. This information is maintained in a system of records designated as NRC-27 and described at 40 Federal Register 45344 (October 1, 1975).

1. AUTHORITY Sections 53, 63, 66, 81, 103, 104, 161(b), and 161(o) of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2073, 2093, 2095, 2111, 2133, 2134, 2201(b), and 2201(o)). The authority for collecting the social security number is 10 CFR Part 20.

2. PRINCIPAL PURPOSE(S) The information is used by the NRC in its evaluation of the risk of radiation exposure associated with the licensed activity and in exercising its statutory responsibility to monitor and regulate the safety and health practices of its licensees. The data permits a meaningful comparison of both current and long-term exposure experience among types of licenses and among licensees within each type. Data on your exposure to radiation is available to you upon request.

3. ROUTINE USES The information may be used to provide data to other Federal and State agencies involved in monitoring and/or evaluating radiation exposure received by individuals employed as radiation workers on a permanent or temporary basis and exposure received by members of the public. The information may also be disclosed to an appropriate Federal, State, or local agency in the event the information indicates a violation or potential violation of law and in the course of an administrative or judicial proceeding.

4. WHETHER DISCLOSURE IS MANDATORY OR VOLUNTARY AND EFFECT ON INDIVIDUAL OF NOT PROVIDING INFORMATION It is voluntary that you furnish the requested information, including social security number; however, the licensee must have a completed Form NRC-4 on each individual whom the licensee proposes to expose to a radiation dose in excess of the amounts specified in 10 CFR 20.101(a). Failure to obtain the requested information before permitting such exposure may subject the licensee to enforcement action in accordance with 10 CFR 20.601. The social security number is used to assure that NRC has an accurate identifier not subject to the coincidence of similar names or birthdates among the large number of persons on whom data is maintained.

5. SYSTEM MANAGER(S) AND ADDRESS Director, Office of Management Information and Program Control
U.S. Nuclear Regulatory Commission, Washington, D.C. 20555

Form NRC-4
(8 79)
10 CFR 20

U. S. NUCLEAR REGULATORY COMMISSION

Approved by GAO
B-180225 (R0078)
Expires - 6-30-77

CURRENT OCCUPATIONAL EXTERNAL RADIATION EXPOSURE

See Instructions on Back

IDENTIFICATION

1. NAME (PRINT – Last, first, and middle)	2. SOCIAL SECURITY NO.
3. DATE OF BIRTH (Month, day, year)	4. NAME OF LICENSEE

5. DOSE RECORDED FOR (Specify: Whole body; skin of whole body; or hands and forearms, feet and ankles.)	6. WHOLE BODY DOSE STATUS (rem)	7. METHOD OF MONITORING (e.g., Film Badge – FB; Pocket Chamber – PC; Calculations – Calc.) X OR GAMMA _____ BETA _____ NEUTRONS _____

8. PERIOD OF EXPOSURE (From – To)	DOSE FOR THE PERIOD (rem)				13. RUNNING TOTAL FOR CALENDAR QUARTER (rem)
	9. X OR GAMMA	10. BETA	11. NEUTRON	12. TOTAL	

LIFETIME ACCUMULATED DOSE

14. PREVIOUS TOTAL (rem)	15. TOTAL QUARTERLY DOSE (deep / shallow)	16. TOTAL ACCUMULATED DOSE (rem)	17. PERS. ACC. DOSE (5(N-18)) (rem)	18. UNUSED PART OF PERMISSIBLE ACCUMULATED DOSE (rem)

INSTRUCTIONS FOR PREPARATION OF FORM NRC-5

The preparation and safekeeping of this form or a clear and legible record containing all the information required on this form is required pursuant to Section 20.401 of "Standards for Protection Against Radiation," 10 CFR 20, as a current record of occupational external radiation exposures. Such a record must be maintained for each individual for whom personnel monitoring is required under Section 20.202. Note that a separate Form NRC-5 is to be used for recording external exposure to (1) the whole body; (2) skin of whole body; (3) hands and forearms; or (4) feet and ankles, as provided by Item 5 below.

Listed below by item are instructions and additional information directly pertinent to completing this form.

Identification

Item 1. Self-explanatory.
Item 2. Self-explanatory except that, if individual has no social security number, the word "none" shall be inserted.
Item 3. Self-explanatory.
Item 4. Self-explanatory.

Occupational Exposure

Item 5. "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. Unless the lenses of the eyes are protected with eye shields, dose recorded as whole body dose should include the dose delivered through a tissue equivalent absorber having a thickness of 300 mg/cm^2 or less. When the lenses of the eyes are protected with eye shields having a tissue equivalent thickness of at least 700 mg/cm^2, dose recorded as whole body dose should include the dose delivered through a tissue equivalent absorber having a thickness of 1,000 mg/cm^2 or less.

Dose recorded as dose to the skin of the whole body, hands and forearms, or feet and ankles should include the dose delivered through a tissue equivalent absorber having a thickness of 7 mg/cm^2 or less. The dose to the skin of the whole body, hands and forearms, or feet and ankles should be recorded on separate forms unless the dose to those parts of the body has been included as dose to the whole body on a form maintained for recording whole body exposure.

Item 6. This item need be completed only when the sheet is used to record whole body exposures and the licensee is exposing the individual under the provisions of Paragraph 20.101(b) which allows up to 3 rems per quarter to the whole body. Enter in this item the unused part of permissible accumulated dose taken from previous records of exposure, i.e., Item 18 of the preceding Form AEC-5 or NRC-5 or Item 13 of Form AEC-4 or NRC-4 if the individual's exposure during employment with the licensee begins with this record.

Item 7. Indicate the method used for monitoring the individual's exposure to each type of radiation to which he is exposed in the course of his duties. Abbreviations may be used.

Item 8. Doses received over a period of less than a calendar quarter need not be separately entered on the form provided that the licensee maintains a current record of the doses received by the individual which have not as yet been entered on the form. The period of exposure should specify the day the measurement of that exposure was initiated and the day on which it was terminated. For example, if only quarterly doses are entered, the period of exposure for the first calendar quarter of 1982 might be taken as running from Monday, January 1, 1982, through Friday, March 30, 1982, and would be indicated in this item as Jan. 1, 1982-Mar. 30, 1982. If weekly doses are entered, a film badge issued Monday morning, January 1, 1982, and picked up Friday, January 8, 1982, would be indicated as Jan. 1, 1982-Jan. 8, 1982.

Items 9, 10 and 11. Self-explanatory. The values are to be given in rem. All measurements are to be interpreted in the best method known and in accordance with Paragraph 20.4(c). Where calculations are made to determine dose, a copy of such calculations is to be maintained in conjunction with this record. In any case where the dose for a calendar quarter is less than 10% of the value specified in Paragraph 20.101(a), the phrase "less than 10%" may be entered in lieu of a numerical value.

Item 12. Add the values under Items 9, 10 and 11 for each period of exposure and record the total. In calculating the "Total" any entry "less than 10%" may be disregarded.

Item 13. The running total is to be maintained on the basis of calendar quarters. Paragraph 20.3(a) (4) defines calendar quarter. No entry need be made in this item if only calendar quarter radiation doses are recorded in Items 9, 10, 11 and 12.

Lifetime Accumulated Dose (Whole Body)

NOTE: If the licensee chooses to keep the individual's exposure below that permitted in Paragraph 20.101(a), Items 14 through 18 need not be completed. However, in that case the total whole body dose for each calendar quarter recorded in Item 13 (or Item 12 if quarterly doses are entered in Item 12) should not exceed 1 1/4 rem.

If an individual is exposed under the provisions of Paragraph 20.101 (b), complete Items 14 through 18 at the end of each calendar quarter and when the sheet is filled. Values in Item 13, when in the middle of a calendar quarter, and values in Item 18, must be brought forward to next sheet for each individual.

Item 14. Enter the previous total accumulated dose from previous dose records for the individual (e.g., from Item 16 of Form AEC-5 or NRC-5 or Item 11 of Form AEC-4 or NRC-4). The total occupational radiation dose received by the individual must be entered in this item, including any occupational dose received from sources of radiation not licensed by the Commission. If the individual was exposed to sources of radiation not licensed by the Commission during any calendar quarter after completing Form AEC-4 or NRC-4 and personnel monitoring equipment was not worn by the individual, it should be assumed that the individual received a dose of 1 1/4 rems during each such calendar quarter.

Item 15. Enter the total calendar quarter dose from Item 13 (or from Item 12 if quarterly doses are entered in Item 12) and the date designating the end of the calendar quarter in which the dose was received (e.g., March 30, 1982).

Item 16. Add Item 14 and Item 15 and enter that sum.

Item 17. Obtain the Permissible Accumulated Dose (PAD) in rem for the WHOLE BODY. "N" is equal to the number of years of age of the individual on his last birthday. Subtract 18 from N and multiply the difference by 5 rem (e.g., John Smith, age 32; N = 32, PAD = 5(32-18) = 70 rem.)

Item 18. Determine the unused part of the PAD by subtracting Item 16 from Item 17. The unused part of the PAD is that portion of the Lifetime Accumulated Dose for the individual remaining at the end of the period covered by this sheet.

PRIVACY ACT STATEMENT

Pursuant to 5 U.S.C. 552a(e) (3), enacted into law by section 3 of the Privacy Act of 1974 (Public Law 93-579), the following statement is furnished to individuals who supply information to the Nuclear Regulatory Commission on Form NRC-5. This information is maintained in a system of records designated as NRC-27 and described at 40 Federal Register 45364 (October 1, 1975).

1. AUTHORITY — Sections 53, 63, 65, 81, 103, 104, 161(b), and 161(o) of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2073, 2093, 2095, 2111, 2133, 2134, 2201(b), and 2201(o)). The authority for soliciting the social security number is 10 CFR Part 20.

2. PRINCIPAL PURPOSE(S) — The information is used by the NRC in its evaluation of the risk of radiation exposure associated with the licensed activity and in exercising its statutory responsibility to monitor and regulate the safety and health practices of its licensees. The data permits a meaningful comparison of both current and long-term exposure experience among types of licensees and among licensees within each type. Data on your exposure to radiation is available to you upon your request.

3. ROUTINE USES — The information may be used to provide data to other Federal and State agencies involved in monitoring and/or evaluating radiation exposure received by individuals employed as radiation workers on a permanent or temporary basis and exposure received by monitored visitors. The information may also be disclosed to an appropriate Federal, State, or local agency in the event the information indicates a violation or potential violation of law and in the course of an administrative or judicial proceeding.

4. WHETHER DISCLOSURE IS MANDATORY OR VOLUNTARY AND EFFECT ON INDIVIDUAL OF NOT PROVIDING INFORMATION — It is voluntary that you furnish the requested information, including social security number; however, the licensee must complete Form NRC-5 on each individual for whom personnel monitoring is required under 10 CFR 20.202. Failure to do so may subject the licensee to enforcement action in accordance with 10 CFR 20.601. The social security number is used to assure that NRC has an accurate identifier not subject to the coincidence of similar names or birthdates among the large number of persons on whom data is maintained.

5. SYSTEM MANAGER(S) AND ADDRESS — Director, Office of Management Information and Program Control, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555