NRC FORM 374
(10-88)

U.S. NUCLEAR REGULATORY COMMISSION

MATERIALS LICENSE

Amendment No. 09

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974 (Public Law 93-438), and Title 10, Code of Federal Regulations, Chapter I, Parts 30, 31, 32, 33, 34, 35, 39, 40 and 70, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, possess, and transfer byproduct, source, and special nuclear material designated below; to use such material for the purpose(s) and at the place(s) designated below; to deliver or transfer such material to persons authorized to receive it in accordance with the regulations of the applicable Part(s). This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, as amended, and is subject to all applicable rules, regulations and orders of the Nuclear Regulatory Commission now or hereafter in effect and to any conditions specified below.

Licensee	
1. Department of Health and Human Services National Institute of Health	In accordance with application dated September 25, 1991, 3. License number 19-00296-20 is amended in its entirety to read as follows:
2. Building 21 9000 Rockville Pike Bethesda, Maryland 20892	4. Expiration date January 31, 1998
	5. Docket or Reference No 030-17872

6. Byproduct, source, and/or special nuclear material	7. Chemical and/or physical form	8. Maximum amount that licensee may possess at any one time under this license
A. Cobalt 60	A. Sealed sources (AECL Capsule Type C-151)	A. 2,000 curies

9. Authorized use

A. For use in AECL Eldorado-78 teletherapy unit to perform irradiation studies on cell cultures and small animals.

CONDITIONS

10. Licensed material shall be used only at National Institue of Health, Building 10, Room B3-B44C-1, 9000 Rockville Pike, Bethesda, Maryland.

11. A. Licensed material shall be used by individuals designated by the NIH Radiation Safety Committee, Dr. Jacob Robbins, Chairman.

B. The Radiation Safety officer for this license is William J. Walker, Ph.D.

12. Sealed sources or detector cells containing licensed material shall not be opened or sources removed from source holders or detector cells by the licensee.

13. A. Sealed sources and detector cells shall be tested for leakage and/or contamination at intervals not to exceed 6 months or at such other intervals as are specified by the certificate of registration referred to in 10 CFR 32.210, not to exceed 3 years.

B. Notwithstanding Paragraph A of this Condition, sealed sources designed to emit alpha particles shall be tested for leakage and/or contamination at intervals not to exceed 3 months.

C. In the absence of a certificate from a transferor indicating that a test has been made within six months prior to the transfer, a sealed source or detector cell received from another person shall not be put into use until tested.

MATERIALS LICENSE
SUPPLEMENTARY SHEET

License number
19-00296-20

Docket or Reference number
030-17872

Amendment No. 09

(13. Continued) CONTINUED

D. Each sealed source fabricated by the licensee shall be inspected and tested for construction defects, leakage, and contamination prior to any use or transfer as a sealed source.

E. Sealed sources and detector cells need not be leak tested if:

(i) they contain only hydrogen 3; or

(ii) they contain only a gas; or

(iii) the half-life of the isotope is 30 days or less; or

(iv) they contain not more than 100 microcuries of beta and/or gamma emitting material or not more than 10 microcuries of alpha emitting material; or

(v) they are not designed to emit alpha particles, are in storage, and are not being used. However, when they are removed from storage for use or transfer to another person, and have not been tested within the required leak test interval, they shall be tested before use or transfer. No sealed source or detector cell shall be stored for a period of more than 10 years without being tested for leakage and/or contamination.

F. The test shall be capable of detecting the presence of 0.005 microcurie of radioactive material on the test sample. Records of leak test results shall be kept in units of microcuries and shall be maintained for inspection by the Commission. If the test reveals the presence of 0.005 microcurie or more of removable contamination, a report shall be filed with the U.S. Nuclear Regulatory Commission and the source shall be removed from service and decontaminated, repaired, or disposed of in accordance with Commission regulations. The report shall be filed within 5 days of the date the leak test result is known with the U.S. Nuclear Regulatory Commission, Region I, ATTN: Chief, Nuclear Materials Safety Branch, 475 Allendale Road, King of Prussia, Pennsylvania 19406. The report shall specify the source involved, the test results, and corrective action taken.

G. The licensee is authorized to collect leak test samples for analysis by the licensee. Alternatively, tests for leakage and/or contamination may be performed by persons specifically licensed by the Commission or an Agreement State to perform such services.

14. The licensee shall not perform repairs or alterations of the irradiator involving removal of shielding or access to the licensed material. Removal, replacement, and disposal of sealed sources in the irradiator shall be performed by a person specifically licensed by the Commission or an Agreement State to perform such services.

15. Licensed material shall not be used in or on human beings.

MATERIALS LICENSE
SUPPLEMENTARY SHEET

License number: 19-00296-20
Docket or Reference number: 030-17872
Amendment No. 09

(Continued) CONDITIONS

16. Before initiation of irradiator operations or after reloading of sources in the irradiator and before restart of the irradiator, a radiation survey shall be conducted to determine the maximum radiation levels in each area adjoining irradiation room with the sources in the shielded position and in the exposed position. The results of the survey shall be sent to the U.S. Nuclear Regulatory Commission, Region I, ATTN: Chief, Nuclear Materials Safety Branch, 475 Allendale Road, King of Prussia, Pennsylvania 19406, not more than thirty days after the survey is conducted.

17. The licensee shall not acquire licensed material in a sealed source or in a device that contains a sealed source unless the source or device has been registered with the Nuclear Regulatory Commission under 10 CFR 32.210 or with an Agreement State.

18. Except as specifically provided otherwise in this license, the licensee shall conduct its program in accordance with the statements, representations, and procedures contained in the documents including any enclosures, listed below. The Nuclear Regulatory Commission's regulations shall govern unless the statements, representations and procedures in the licensee's application and correspondence are more restrictive than the regulations.

A. Application dated September 25, 1991

For the U.S. Nuclear Regulatory Commission

Date DEC 22 1992

By Original Signed By:
Duncan White
Nuclear Materials Safety Branch
Region I
King of Prussia, Pennsylvania 19406

DEC 22 1992

License No. 19-00296-20
Docket No. 030-17872
Control No. 115574

Department of Health & Human Services
National Institute of Health
ATTN: William J. Walker, Ph.D.
Radiation Safety Officer
9000 Rockville Pike Building 21
Bethesda, Maryland 20892

Dear Dr. Walker:

Please find enclosed the renewal of your NRC Material License.

Please review the enclosed document carefully and be sure that you understand all conditions. If there are any errors or questions, please notify the Region I Material Licensing Section, (215) 337-5093, so that we can provide appropriate corrections and answers.

Please be advised that you must conduct your program involving licensed radioactive materials in accordance with the conditions of your NRC license, representations made in your license application, and NRC regulations. In particular, please note the items in the enclosed, "Requirements for Materials Licensees."

Since serious consequences to employees and the public can result from failure to comply with NRC requirements, the NRC expects licensees to pay meticulous attention to detail and to achieve the high standard of compliance which the NRC expects of its licensees.

You will be periodically inspected by NRC. A fee may be charged for inspections in accordance with 10 CFR Part 170. Failure to conduct your program safely and in accordance with NRC regulations, license conditions, and representations made in your license application and supplemental correspondence with NRC will result in prompt and vigorous enforcement action against you. This could include issuance of a notice of violation, or in case of serious violations, an imposition of a civil penalty or an order suspending, modifying or revoking your license as specified in the General Policy and Procedures for NRC Enforcement Actions, 10 CFR Part 2, Appendix C.

We wish you success in operating a safe and effective licensed program.

Sincerely,

Original Signed By:
Duncan White

Duncan White
Nuclear Materials Safety Branch
Division of Radiation Safety
and Safeguards

Enclosures:
1. Amendment No. 09
2. Requirements for Materials Licensees
3. NRC Forms 3 and 313

DRSS:RI
White/gcb

12/22/92

OFFICIAL RECORD COPY - G:\WPS\MLTR\L1900296.20 - 12/21/92

OCT 11 1991

Docket No. 030-17872
License No. 19-00296-20
Control No. 115574

Department of Health & Human Services
ATTN: William J. Walker, Ph.D.
Radiation Safety Officer
9000 Rockville Pike
Building 21 R
Bethesda, Maryland 20892

Dear Mr. Walker:

SUBJECT: LICENSE RENEWAL APPLICATION

This is to acknowledge receipt of your application for renewal of material(s) license identified above. Your application is deemed timely filed, and accordingly, the license will not expire until final action has been taken by this office.

Any correspondence regarding the renewal application should reference the control number specified above.

Sincerely,

Original Signed By:
Cheryl K. Buraker

for Sheryl Villar, Chief
Licensing Assistant Section
Division of Radiation Safety
and Safeguards

RJB 10/10/91

CKB 10/11/91

OFFICIAL RECORD COPY DTL/HEALTH & HUMAN - 0001.0.0
10/08/91

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

030-17872

National Institutes of Health
Bethesda, Maryland 20892
Building : 21
Room : 110
(301) 496- 2254

September 25, 1991

U.S. Nuclear Regulatory Commission
Region I
Nuclear Materials Safety Section A
Division of Radiation Safety and Safeguards
475 Allendale Road
King of Prussia, PA 19406

Re: License No. 19-00296-20

Dear Sir or Ma:

Enclosed is a completed NRC Form 313, "Application for Material License", requesting renewal of License No. 19-00296-20 for the National Institutes of Health.

This renewal application is being submitted in duplicate in its entirety. If clarification is needed or additional information is required, please contact me.

Sincerely,

William J. Walker, Ph.D.
Radiation Safety Officer, NIH

Enclosure in duplicate

115574

OFFICIAL RECORD COPY ML 10

SEP 2 6 1991

NRC FORM 313
(9-91)
10 CFR 30, 32, 33, 34, 35 and 40

U.S. NUCLEAR REGULATORY COMMISSION

APPLICATION FOR MATERIAL LICENSE

APPROVED BY OMB NO. 3150-0120
EXPIRES 6/30/93

ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST: 3.25 HRS. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE INFORMATION AND RECORDS MANAGEMENT BRANCH (MNBB 7714), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC 20555, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0120), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC 20503.

INSTRUCTIONS: SEE THE APPROPRIATE LICENSE APPLICATION GUIDE FOR DETAILED INSTRUCTIONS FOR COMPLETING APPLICATION. SEND TWO COPIES OF THE ENTIRE COMPLETED APPLICATION TO THE NRC OFFICE SPECIFIED BELOW.

APPLICATIONS FOR DISTRIBUTION OF EXEMPT PRODUCTS FILE APPLICATIONS WITH:

U.S. NUCLEAR REGULATORY COMMISSION
DIVISION OF INDUSTRIAL AND MEDICAL NUCLEAR SAFETY, NMSS
WASHINGTON, DC 20555

ALL OTHER PERSONS FILE APPLICATIONS AS FOLLOWS. IF YOU ARE LOCATED IN:

CONNECTICUT, DELAWARE, DISTRICT OF COLUMBIA, MAINE, MARYLAND, MASSACHUSETTS, NEW HAMPSHIRE, NEW JERSEY, NEW YORK, PENNSYLVANIA, RHODE ISLAND, OR VERMONT, **SEND APPLICATIONS TO:**

U.S. NUCLEAR REGULATORY COMMISSION, REGION I
NUCLEAR MATERIALS SAFETY SECTION B
475 ALLENDALE ROAD
KING OF PRUSSIA, PA 19406

ALABAMA, FLORIDA, GEORGIA, KENTUCKY, MISSISSIPPI, NORTH CAROLINA, PUERTO RICO, SOUTH CAROLINA, TENNESSEE, VIRGINIA, VIRGIN ISLANDS, OR WEST VIRGINIA, **SEND APPLICATIONS TO:**

U.S. NUCLEAR REGULATORY COMMISSION, REGION II
NUCLEAR MATERIALS SAFETY SECTION
101 MARIETTA STREET, SUITE 2900
ATLANTA, GA 30323

IF YOU ARE LOCATED IN:

ILLINOIS, INDIANA, IOWA, MICHIGAN, MINNESOTA, MISSOURI, OHIO, OR WISCONSIN, **SEND APPLICATIONS TO:**

U.S. NUCLEAR REGULATORY COMMISSION, REGION III
MATERIALS LICENSING SECTION
799 ROOSEVELT ROAD
GLEN ELLYN, IL 60137

ARKANSAS, COLORADO, IDAHO, KANSAS, LOUISIANA, MONTANA, NEBRASKA, NEW MEXICO, NORTH DAKOTA, OKLAHOMA, SOUTH DAKOTA, TEXAS, UTAH, OR WYOMING, **SEND APPLICATIONS TO:**

U.S. NUCLEAR REGULATORY COMMISSION, REGION IV
MATERIAL RADIATION PROTECTION SECTION
611 RYAN PLAZA DRIVE, SUITE 1000
ARLINGTON, TX 76011

ALASKA, ARIZONA, CALIFORNIA, HAWAII, NEVADA, OREGON, WASHINGTON, AND U.S. TERRITORIES AND POSSESSIONS IN THE PACIFIC, **SEND APPLICATIONS TO:**

U.S. NUCLEAR REGULATORY COMMISSION, REGION V
NUCLEAR MATERIALS SAFETY SECTION
1450 MARIA LANE, SUITE 210
WALNUT CREEK, CA 94596

PERSONS LOCATED IN AGREEMENT STATES SEND APPLICATIONS TO THE U.S. NUCLEAR REGULATORY COMMISSION ONLY IF THEY WISH TO POSSESS AND USE LICENSED MATERIAL IN STATES SUBJECT TO U.S. NUCLEAR REGULATORY COMMISSION JURISDICTION.

1. THIS IS AN APPLICATION FOR *(Check appropriate item)*:

- [ ] A. NEW LICENSE
- [ ] B. AMENDMENT TO LICENSE NUMBER _____
- [X] C. RENEWAL OF LICENSE NUMBER 19-000296-20

2. NAME AND MAILING ADDRESS OF APPLICANT *(Include Zip Code)*:

Department of Health and Human Services
National Institutes of Health
Building 21 9000 Rockville Pike
Bethesda, Maryland 20892

3. ADDRESS(ES) WHERE LICENSED MATERIAL WILL BE USED OR POSSESSED:

National Institutes of Health
9000 Rockville Pike
Bethesda, Maryland 20892

4. NAME OF PERSON TO BE CONTACTED ABOUT THIS APPLICATION: Dr. William J. Walker, Radiation Safety Officer, NIH

TELEPHONE NUMBER: (301) 496-2254

SUBMIT ITEMS 5 THROUGH 11 ON 8½ x 11" PAPER. THE TYPE AND SCOPE OF INFORMATION TO BE PROVIDED IS DESCRIBED IN THE LICENSE APPLICATION GUIDE.

5. RADIOACTIVE MATERIAL
a. Element and mass number, b. chemical and/or physical form, and c. maximum amount which will be possessed at any one time

6. PURPOSE(S) FOR WHICH LICENSED MATERIAL WILL BE USED

7. INDIVIDUAL(S) RESPONSIBLE FOR RADIATION SAFETY PROGRAM AND THEIR TRAINING AND EXPERIENCE

8. TRAINING FOR INDIVIDUALS WORKING IN OR FREQUENTING RESTRICTED AREAS

9. FACILITIES AND EQUIPMENT

10. RADIATION SAFETY PROGRAM

11. WASTE MANAGEMENT

12. LICENSE FEES *(See 10 CFR 170 and Section 170.31)*
FEE CATEGORY | AMOUNT ENCLOSED: $

13. CERTIFICATION *(Must be completed by applicant)*. THE APPLICANT UNDERSTANDS THAT ALL STATEMENTS AND REPRESENTATIONS MADE IN THIS APPLICATION ARE BINDING UPON THE APPLICANT.

THE APPLICANT AND ANY OFFICIAL EXECUTING THIS CERTIFICATION ON BEHALF OF THE APPLICANT, NAMED IN ITEM 2, CERTIFY THAT THIS APPLICATION IS PREPARED IN CONFORMITY WITH TITLE 10, CODE OF FEDERAL REGULATIONS, PARTS 30, 32, 33, 34, 35, AND 40 AND THAT ALL INFORMATION CONTAINED HEREIN IS TRUE AND CORRECT TO THE BEST OF THEIR KNOWLEDGE AND BELIEF.

WARNING: 18 U.S.C. SECTION 1001 ACT OF JUNE 25, 1948, 62 STAT. 749 MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

SIGNATURE - CERTIFYING OFFICER	TYPED/PRINTED NAME	TITLE	DATE
William Walker	William J. Walker, Ph.D.	Radiation Safety Officer	9/25/91

FOR NRC USE ONLY

TYPE OF FEE	FEE LOG	FEE CATEGORY	COMMENTS
		FEE EXEMPT	

AMOUNT RECEIVED	CHECK NUMBER

APPROVED BY | DATE

NRC FORM 313 (9-91)

Attachment to NRC Form 313:

Renewal of License No. 19-00296-20
September 25, 1991
National Institutes of Health
Bethesda, Maryland 20892

Item 5. Radioactive Material

a. Cobalt 60
b. Sealed source (AECL Capsule Type C-151)
c. Not to exceed 2,000 Curies

Item 6. Purpose(s) For Which Licensed Material Will Be Used

To be used in an AECL Eldorado 78 Cobalt-60 Teletherapy unit to irradiate cell cultures and small animals only in radiobiology research program. This irradiator will not be used to irradiate humans nor will it be used as an industrial type irradiator.

Item 7. Individual(s) Responsible For Radiation Safety Program and Their Training and Experience

The NIH Radiation Safety Organization is shown on the following charts. The Radiation Safety Officer (RSO) is appointed by the Director of NIH. A resume of the training and experience of the RSO is attached. Additional information is presented in Item 10. Radiation Safety Program. The daily operation of this irradiator will be supervised by the Authorized Custodian as described in the attached Radiation Safety Procedures Manual for Operation of Irradiator (Eldorado78), hereafter referred to as the Manual (see Attachment 313-7). Training and experience requirements for the Authorized Custodian are given in the Manual.

Item 8. Training for Individuals Working in or Frequenting Restricted Areas

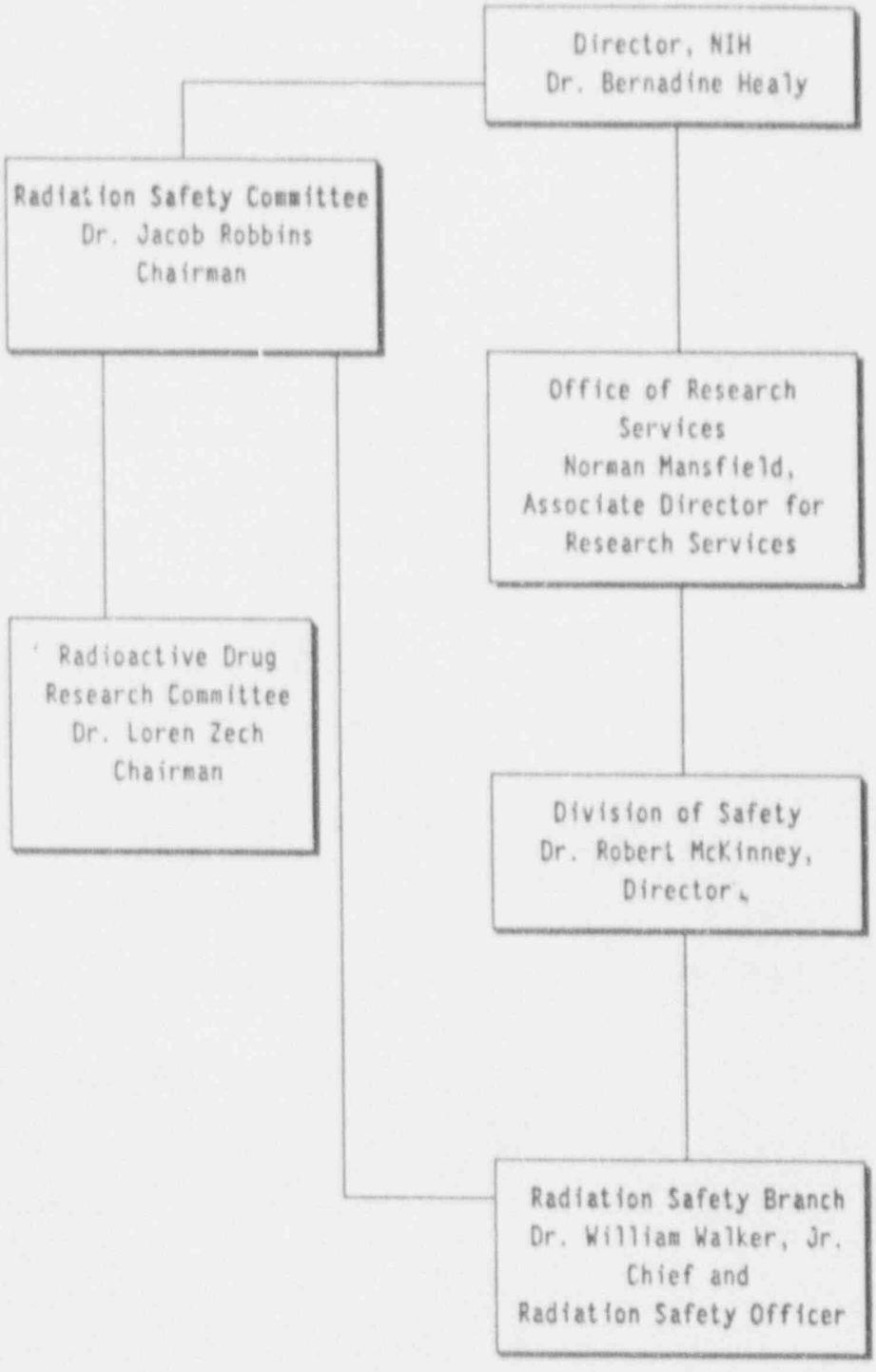
The irradiator shall be used only by or under the supervision of an Authorized Custodian approved by the Chairperson, NIH Radiation Safety Committee. Operators of the irradiator shall be Designated Users approved by the Authorized Custodian. Procedures for becoming an Authorized Custodian or Designated User and the training requirements are detailed in the attached Manual.

Item 9. Facilities and Equipment

The irradiator for which this license renewal is sought has been previously evaluated and licensed by the NRC and has been approved for unattended operation. A description of the irradiator, including the interlock system and other safety features, is included in the Manual.

The physical location of this irradiator is NIH, Building 10, Room B3-B44C-1. This room also contains a megavoltage (4 MeV) X-ray unit used only to irradiate cell cultures and small animals in the radiobiology research program. A copy of the initial radiation survey performed in November 1989 to verify the shielding of this facility is included as Attachment 313-9.

NATIONAL INSTITUTES OF HEALTH RADIATION SAFETY ORGANIZATION



Radiation Safety Branch, DS
Functional Organization
September 1991

RESUME

WILLIAM J. WALKER, JR., Ph.D., CHP
Chief, Radiation Safety Branch and
Radiation Safety Officer
Division of Safety
National Institutes of Health
Bethesda, Maryland

EDUCATION

University of Florida
Gainesville, Florida
Doctor of Philosophy Degree - Environmental Engineering
(Radiological Health) 1971

University of Kansas
Lawrence, Kansas
Master of Science Degree - Radiation Biophysics 1964

Virginia Military Institute
Lexington, Virginia
Bachelor of Science Degree - Civil Engineering 1958

CERTIFICATIONS AND LICENSES

- Certified Health Physicist, American Board of Health Physics
- Registered Professional Engineer (Civil and Sanitary Engineering)
- Qualified Expert as a Radiation Inspector, State of Virginia
- Qualified Expert as a Radiation Machine Inspector, State of Maryland

AFFILIATIONS

- Member, Health Physics Society
- Chairman, Board of Directors, Profound Paralysis Foundation
- Member, Society of Sigma XI
- Member and Officer, Lions Club International
- Member(inactive), American College of Nuclear Physicians
- Member(inactive), American Association of Physicists in Medicine
- Member(inactive), American College of Medical Physics
- Member(inactive), Society of Nuclear Medicine

PROFESSIONAL ACTIVITIES

- Secretary/Treasurer (1973 - 1975)
  Mid-Atlantic Chapter
  American Association of Physicists in Medicine

- President (1976 - 1977)
  Mid-Atlantic Chapter
  American Association of Physicists in Medicine

- American College of Nuclear Physicians
  Committees (1989)
  - Nuclear Medicine Science Committee
  - Standardization of Nuclear Medicine Instrumentation Committee
  - Government Affairs Committee
  - Equipment Specifications and Performance Committee
  - Subcommittee on Nuclear Medicine Technology

- American Board of Health Physics Part 1 Certification Exam Panel (Current)

CURRENT POSITION

[illegible] the NIH Radiation Safety Officer and as Chief of the Radiation Safety Branch. [illegible]ministrator and technical director of the Branch. Conceives, plans, coordinates and [illegible]ects through the two subordinate section chiefs, programs of education, training, surveillance, risk assessment, technical assistance, and support services which collectively serve to create a safe and healthful environment for the use of radiation sources by employees, guest workers, patients, and visitors of the NIH. As the NIH Radiation Safety Officer is appointed by the Director of NIH and is responsible for the regulatory aspects of the NIH Radiation Safety Program including licensing activities, compliance with Federal regulations, and the implementation of an effective compliance and enforcement program for NIH workers.

The National Institutes of Health campus constitutes the world's largest biomedical research installation. The NIH Radiation Safety Branch provides compliance oversight and consulting services to over two thousand laboratories on the NIH campus and in four remote locations. The Branch is staffed by 33 personnel, including 22 professional Health Physicists. During the course of a year, the Branch provides radiation safety training to approximately 5000 scientists and other NIH staff, makes about 66,000 radioactive waste pickups, receives, processes and redistributes over 34,000 shipments of radioisotopes, and performs over 10,000 surveys and inspections.

WORK EXPERIENCE

1. U.S.Nuclear Regulatory Commission
Washington, D.C.
May 1989 - August 1989

Consultant (full time) to the Director, State, Local and Indian Tribe Programs (SLITP), Office of Government and Public Affairs. Participated in the development and revision of Suggested State Regulations, review of proposed Agreement State regulations and the revision of SLITP Internal Procedures.

2. The Institute for Radiological Imaging Sciences, Inc. (IRIS),
Germantown, Maryland
(November 1988 - August 1989)

Senior Consultant in Radiological Physics. Provided consulting services in quality assurance, imaging sciences and radiological health to a wide range of governmental and industry clients.

3. Sacred Heart Hospital,
Allentown, Pennsylvania
(November 1984 - Present)

Consulting Radiological Physicist. Provides radiation therapy physics support to the Department of Radiotherapy. Acts as consultant to the hospital's Radiation Safety Officer in radiation safety, regulatory compliance and other quality assurance program issues.

4. Radiopharmaceutical Management Services, Inc.,
Rockville, Maryland
(January - November 1988)

President and Chief operating officer of this one million dollar a year technical/sales firm. Responsible for restructuring and restoring client acceptance and establishing corporate profitability. These goals were met and exceeded.

Managed a technical and administrative staff with two operating locations. Responsible for all budgeting, long and short term planning, personnel management, client relations, regulatory (NRC, FDA and other state and local governments) relations, and business development. Provided professional health/medical physics support to clients.

5. Health Physics Services, Inc.,
Rockville, Maryland
(October 1985 - November 1988)

Senior Vice President and Chief Scientist. Duties of an executive managerial and technical nature pertaining to the business and professional services of the firm. Actively involved in seeking and developing new business, development and negotiation of proposals, maintaining high standards of quality control, development of computer protocols and related technical procedures, enhancement of client relations, and representing the firm at various scientific and professional meetings.

Responsible for providing professional health/radiological physics support including therapy physics, environmental science and engineering support, assisting in the development of corporate policy including short term and long term strategy planning. Assisted in the management of fourteen personnel and reported directly to the President of the company.

6. RSO, Inc.,
Laurel, Maryland
(October 1983 - October 1984)

Vice President, Medical Division. Responsible for Medical Division operations, planning, and development. Acted as principle corporate consultant in medical and health physics. Implemented an internal corporate quality assurance program. Principle investigator on DOE SBIR contract to study feasibility of a centralized facility for volume reduction and disposal of low-level radioactive biomedical research waste. Consultant to academic institutions, research and medical facilities, and industrial radiation users.

7. U.S. Nuclear Regulatory Commission
Washington, D.C.
(1978 - 1983)

Section Leader, Medical and Academic Licensing Section. Managed a high-level technical staff involved in the review and processing of new applications, renewals, and amendments to existing license for byproduct, source, and special nuclear materials (10,000 active licenses; 5,000 - 6,000 license actions processed annually). Section staff also conducted safety analyses, environmental impact assessments, and special projects. Also served as Section Leader for Industrial Licensing section for an eight month period.

Chaired 16 member intra-agency task force for revision of Part 35 regulation. Coordinated 9 member Advisory Committee on the Medical Use of Isotopes, a panel of experts from the medical community who provide advice and recommendations to the NRC. Also acted as key NRC contact for the Veterans Administration and DOD agencies in matters of medical licensing.

Completed NRC SES Candidate Development Program. As part of program, was detailed to the Subcommittee on Nuclear Regulation of the U.S. Senate Committee on Environment and Public Works for four months. Responsible for technical reviews of NRC, FEMA, and EPA budgets, was staff coordinator for a major Subcommittee hearing.

8. Malcolm Grow U.S. Air Force Medical Center
Andrew Air Force Base
Washington, D.C.
(1971 - 1978)

Chief of Medical Physics. Reorganized and directed health and medical physics programs (included such activities and treatment planning for teletherapy patients, diagnostic x-ray quality assurance programs, and licensing). Supervised staff. Served as Radiation Safety Officer. Developed and conducted x-ray and Nuclear Medicine Technology courses, and annual medical physics review course for military and civilian radiology residents. Developed and implemented a new format for the DOD's Radiology Uniform Chart of Accounts (a resource accounting system). Provided technical advice on health physics and nuclear medical to Air force Headquarters Command and air Force Inspector General.

Also served as Command Health Physicist, Headquarters Command, United States Air force; Instructor, Department of Biological and Physical Sciences, Prince Georges Community College, Largo, Maryland; and Consultant in Diagnostic Radiology, Nuclear Medicine and Radiation Safety, Children's Hospital National Medical Center, Washington, D.C.

9. Physics Control Incorporated (1973 - 1978)
Waldorf, Maryland
President, Principal Consultant

10. Air Force Weapons Laboratory, Kirtland Air Force Base (1964 - 1968)
Albuquerque, New Mexico
Research Health Physicist

11. Headquarters, 7th Air Division (SAC) (1960 - 1962)
High Wycombe, England
Staff Environmental Engineer

12. Castle Air Force Base, California (1958 - 1960)
Base Sanitary and Industrial Hygiene Engineer

PUBLICATIONS

Walker, William J., Jr., "Grasshopper Embryos as a Biological Radiation Dosimeter, "Master of Science Thesis, University of Kansas, 1964.

Walker, William J., Jr., and Edward I. Shaw, "Rearing of Chortophaga Viridifasciata for Biological Studies", Transactions of the Kansas Academy of Science, Vol. 67, No. 3, 539-543, 1964.

Walker, William J., Jr., and Jelle de Boer, "Development of a Shield for Partial Body Irradiation by Pulsed Fission Spectrum Radiations", Air Force Weapons Laboratory Technical Report No. 66-23, January 1967.

Mobley, Thomas S., William J. Walker, Jr., and Jelle de Boer, "Lethal Dose Studies on Sheep Exposed to Pulsed Fission Spectrum Radiation (PRSR)", Air Force Weapons Laboratory Technical Report No. 65-199, June 1967.

Hauver, R.C., Vincent T. Penikas, William J. Walker, Jr., Max M. Nold, and Thomas S. Mobley, "Exposure of Sheep to Millisecond Verses Micro-second Fission Radiation". In the Proceedings of the Symposium - Dose Rate in Mammalian Radiation Biology, ORNL. CONF. - 680410.

Walker, William J., Jr., Francis J. Connolly, and Frank S. Dombek,
"A 5-Kilocurie Cobalt-60 Large Animal Irradiation Facility", Air Force Weapons Laboratory Technical Report No. 68-16, July 1968.

Hauver, Robert C. and William J. Walker, Jr., Effects of Millisecond Versus Microsecond Pulses of Fission Spectrum Radiation of Sheep: "Lethality Studies", Air Force Weapons Laboratory Technical Report No. 68-94, October 1968.

Walker, William J., Jr., "The Nature and Control of External Sources of Variation in Whole Body Counting", Doctoral Dissertation, University of Florida 1971.

Walker, William J., Jr., J. L. Campbell, and R. J. Carella, "Cobalt-60 Teletherapy Simulation Devise for Simple Treatment Fields", Phys. Med. Biol. Vol. 19, No. 2, March 1974.

Walker, William J., Jr., Edward S. Barnes, and Hector Lopez, "Radium Leaks", U.S. Air Force Medical Service Digest, Vol. XXV, No. 3, March 1974.

Walker, William J., Jr., John L. Campbell, and Richard J. Carella, "A Simple Beam Defining and Localization System for Cobalt-60 Teletherapy", U.S. Air Force Medical Service Digest, Vol. XXV, No. 4, April 1974.

Siegel, Michael E., William J. Walker, Jr., and John L. Campbell, II, "Accumulation of Tc-99m - Diphosphonate in Malignant Pleural Effusions: Detection and Verification", J. Nuclear Medicine, Vol. 16, No. 10,
pp. 883-885, October 1975.

Walker, William J., Jr., Billy Dunavant, Genevieve Roessler, Charles E. Roessler, and W. Emmett Bolch, "An Evaluation of Radon Daughters as a Cause of Background Variations in a Whole Body Counter", presented at the Annual Meeting - Health Physics Society, 1974.

Walker, William J., Jr., "Program for Diagnostic X-ray Quality Assurance in the Hospital Radiology Department", Application of Optical Instrumentation in Medicine, IV, presented by the Society of Photo-Optical Instrumentation Engineers, Atlanta, September 25-27, 1974. Invited Paper.

Steinfeld, Alan D., and William J. Walker, Jr., "Radiation Hazards Around the Home", U.S. Air Force Medical Service Digest, Vol. XXVII, No. 3. Summer, 1977.

Walker, William J., Jr., "Nuclear Regulatory Commission Licensing Policies and Regulations for Effective Radioactive Waste Management at Medical and Academic Institutions", presented at the Annual Meeting - Health Physics Society, 1981.

Attachment to NRC Form 313:

Renewal of License No. 19-00296-20
September 25, 1991
National Institutes of Health
Bethesda, Maryland 20892

Item 9. continued

This irradiator will not be moved from its present location without the permission of the U.S. Nuclear Regulatory Commission.

A description of radiation monitoring instrumentation available, calibration procedures, personnel monitoring and other program information is included in Item 10. Radiation Safety Program.

Item 10. Radiation Safety Program

The NIH Radiation Safety Program is described in the attached copy of the NIH Radiation Safety Guide (Attachment 313-10). Additional supportive information is as follows:

Radiation Safety Committee

The NIH Radiation Safety Committee is appointed by the Director of NIH and its membership is consistent with NRC guidelines. The Committee is comprised of members representing major classes of users of radioactive rmaterials and radiation sources, the nursing services, NIH management and the NIH Radiation Sarety Officer with provision to allow additional members as needed or desirable. The functions and responsibilities of the NIH Radiation Safety Committee are presented on page 1 of the NIH Radiation Safety Guide. Certain responsibilities and authorities of the Committee may be delegated to the Radiation Safety Officer to facilitate the operation of the NiH Radiation Safety Program.

Radiation Safety Officer

The Radiation Safety Officer is appointed by the Director of NIH. His resume is provided under Item 7 of this application. The RSO is also Chief of the Radiation Safety Branch which administers the NIH Radiation Safety Program. The RSO is responsible for the direction of the Radiation Safety Program. These responsibilities are presented on page 2 of the NIH Radiation Safety Guide. The organizational chart provided in Item 7 shows the relationship of the Radiation Safety Branch, Radiation Safety Officer, Division of Safety, Radiation Safety Committee and the Director of NIH.

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Item 10. continued

Personnel Monitoring Equipment

Irradiator users are required to be part of the personnel monitoring program and are required to wear a whole body exposure monitor when using an irradiator. The personnel monitoring service is currently provided by R. S. Landauer, Jr. and Co. The frequency of change for monitors is at least monthly for film monitors and quarterly for TLDs. Investigations are performed for radiation exposures, as reported by the contractor, which are equal to or greater than 10% of the allowable limits for occupational radiation workers. Corrective actions are implemented as warranted.

Radiation Detection Instruments

Instrumentation pertinent to irradiator radiation safety and available for use by the Radiation Safety Branch includes numerous ion chamber type instruments which can measure up to several hundred milliRoentgen/hour. Other instruments available include numerous GM survey meters, a number of multi-detector survey kits issued to each Health Physicist, instrument systems for laboratory analysis of samples, smears, air samples, etc., including gamma counters, liquid scintillation counters and high-resolution multichannel analyzers. Radiation Safety instrumentation is updated frequently as new and better instruments become available.

Radiation monitoring instruments for use by Radiation Safety Branch Health Physicists are calibrated annually and after servicing by qualified contractors who are licensed by the NRC or an Agreement State. Calibration is performed in compliance with procedures in Appendix B of Regulatory Guide 10.8 (Revision 2, August 1987). Instruments are calibrated so that the readings are within $\pm$ 20% of the actual values over the range of the instrument. Calibration records are kept for a minimum of 3 years.

Leak Testing

Leak testing will be performed as described in the attached Manual.

Operating and Emergency Procedures

Irradiator users will be provided with written operating and emergency procedures. A copy of the Manual will be kept at the irradiator and emergency procedures will be conspicuously posted in the area.

Attachment to NRC Form 313:

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Item 11. Waste Management

No radioactive waste is expected to be generated by use of this irradiator. The sealed source of cobalt-60, if replaced or otherwise not continued to be used, will be returned to the manufacturer if possible or disposed as radioactive waste through our radioactive waste disposal contractor, Radiation Service Organization, Inc., or their successor.

ATTACHMENT 313-7

This page revised: 9/91

National Institutes of Health

Division of Safety

Radiation Safety Branch

RADIATION SAFETY PROCEDURES MANUAL

FOR

OPERATION OF IRRADIATOR
(ELDORADO 78)

IN CASE OF ANY EMERGENCY INVOLVING THIS IRRADIATOR, CALL RADIATION SAFETY AT 496-5774. AFTER NORMAL WORKING HOURS, CALL 116 AND REQUEST RADIATION SAFETY ASSISTANCE.

Manufacturer of Irradiator	:	Atomic Energy of Canada Limited (AECL)
Model	:	Eldorado 78
Radionuclide	:	Cobalt 60
Rated Capacity	:	2000 Curies
Source Activity	:	356 Curies on 9/10/91
Location of Irradiator	:	Building 10 Room B3-B44C-1
Individual Responsible for Supervision of Use (Authorized Custodian)	:	Dr. James Mitchell Name
		Building 10 Room B3-B69 Address
		496-7511 Telephone

U.S. Nuclear Regulatory Commission License Number: 19-00296-20

TABLE OF CONTENTS

Certificate Of Measurement

of

TELETHERAPY SOURCE S3114

for

CUSTOMER National Institutes of Health
Bethesda, Maryland

AECL ORDER No. P&S 41289

THERAPY UNIT OUTPUT When installed in Eldorado 78 #61 (at maximum field size) the exposure rate will be 29.7 Rmm* (±5%), based on the source measurement (below), and the equipment conversion ratio described on sheet 3.

MEASUREMENT OF SOURCE Source S3114 is a 2.0 cm diameter standard source, type C-151 Co60C, containing 1426 curies of cobalt 60. The source exposure rate was 27.8 Rmm (±3%) at the one metre position of the measurement cell.

DATE OF MEASUREMENT As of February 20, 1981

MEASUREMENT METHOD

The source exposure rate was measured in the cell described on the following sheet (Form QC 9 Sheet 2). The exposure rate was measured with an air wall cavity ionization chamber having a volume of 0.6 cm^3 and fitted with a 4.6 mm lucite equilibrium cap. The instrument is calibrated in a cobalt-60 exposure rate certified by the National Research Council of Canada.

ACCURACY

The uncertainty in the source exposure rate applies only to measurement of this source in the AECL Measurement Cell. It represents the maximum total uncertainty due to all causes including the calibration of the Council's primary exposure rate, the calibration of their instrumentation and the precision of measurement in the Measurement Cell. Additional uncertainty due to the comparative measurements involved, has been included in the statement of unit output.

EXCERPT FROM THE RECOMMENDATIONS OF THE INTERNATIONAL COMMISSION ON RADIATION UNITS & MEASUREMENTS, REPORT ICRU-23, OCTOBER 1973. "It must be emphasized the measurement of exposure rate and/or absorbed dose for treatment purposes should be made locally by the user himself. The statement of equipment conversion ratio by the manufacturer should not be regarded as a substitute for this."

ISSUED 1981 February 27

APPROVED P.D. Lancue
Measurement

I. Vajcovec
Quality Control

Atomic Energy of Canada Limited

Ottawa Canada

* NOTE: Rmm stands for roentgens per minute at one metre.

FORM CC 9 - SHEET 1 5/73

INTRODUCTION

The AECL Eldorado 78 cobalt-60 irradiator is a high activity sealed source machine which is capable of producing uniform radiation fields for radiobiological research. This unit is licensed by the U.S. Nuclear Regulatory Commission to contain up to 2000 Ci of cobalt-60 and is used to irradiate cells and small animals for research purposes only. This irradiator will never be used to irradiate humans and will not be used as an industrial type irradiator.

The irradiator is installed at the NIH, Building 10, Room B3-B44C-1. This heavily shielded room is in the third subbasement of the Clinical Center in the Radiation Oncology Branch. This is a controlled access area that is secured after normal working hours. Housekeeping, engineering and other ancillary personnel are not permitted in the area after hours.

The cobalt-60 source supplied by AECL is doubly encapsulated in stainless steel. A measurement certificate is supplied with the source. The source is pneumatically driven and, when not in use, is contained in a heavily shielded sourcehead. The source can be brought to the "Beam On" position only when the sourcehead is directed at the floor or the west wall of the irradiator room. The sourcehead securely shields the cobalt-60 when the machine is not in use and requires key controlled power activation to move the source to the "Beam On" position. The key switch is mounted on the control console located in B3-B44 outside the irradiator room. Safety interlocks and other protective devices must be properly engaged in order for the machine to emit radiation. Emergency stop pushbuttons are located on the control console, the west wall of B3-B44C-1 and on either side of the main frame of the unit. Interruption of any safety device will return the source to the "Beam Off" position.

This irradiator has been approved for continuous use without the Authorized Custodian or a Designated User present as long as the conditions of this manual are followed. Access controls and warning devices used during unattended use are detailed in the section, Description of Irradiator. More specific details of operation are covered in the manufacturer's operations manual (Appendix C).

EMERGENCY PROCEDURES

Alarm Conditions

An area radiation monitor is installed in the room housing the irradiator to indicate hazardous exposures via audible and visual alarms which will be activated if the door is opened and the cobalt-60 source retraction mechanism has malfunctioned leaving the source in the unshielded position. Also, the large warning lights at the door entrances to B3-B44C and B3-B44C-1 and inside B3-B44C-1, the red light on the control console and the red light on the irradiator itself (seen via TV monitor) will remain lit if the source remains in the "Beam On" position. See Drawing 1 for location of radiation monitor and warning lights. Should any of these conditions exist, i.e., audible alarm sounds and/or warning lights remain lit when door to B3-B44C-1 is opened, the irradiator is to be taken out of service at once and the following steps taken:

(1) Do not enter the room.
Secure door to irradiator room. Secure keys to irradiator control console. Doors to B3-B44C and B3-B44 should be locked.

(2) Notify the Radiation Safety Branch at 496-5774. If after normal working hours, dial 116 to get the NIH Fire Department. The NIH Fire Department will use the Emergency Call List to obtain assistance from Radiation Safety Branch staff.

(3) Notify the Authorized Custodian shown on the cover of this manual.

(4) Do not attempt to repair the irradiator.

(5) Do not attempt to operate the irradiator without clearance from the Radiation Safety Branch.

(6) Give a written description of the event in the use log.

Contact the Radiation Safety Branch at 496-5774 if there are any questions about the safety of the irradiator.

An emergency procedure sheet is posted at the control console and at the irradiator.

For more information on safety systems see the section of the manual entitled Description of Irradiator.

PROCEDURES FOR GAINING AUTHORIZATION TO USE IRRADIATOR

Authorized Custodians

Irradiators shall be used under the supervision of individuals so authorized by the Chairperson, Radiation Safety Committee; those individuals shall be termed "Authorized Custodians".

An individual may become the Authorized Custodian by submitting a memorandum applying to be so designated to the Chairperson, Radiation Safety Committee, through the Radiation Safety Officer. In order to be approved, the memorandum must contain the following:

(1) Evidence of meeting the "Training Requirements" contained in this manual.
(2) Specification of the irradiator for which the individual is applying to be the Authorized Custodian including the manufacturer, model, radionuclide in sealed source contained in the irradiator and the activity, the building and room number where the irradiator is located and the individual's title, Institute, Center or Division (ICD) and organizational subunit.
(3) A statement by the applicant that he/she will be responsible for supervising the use of the irradiator in accordance with the provisions of this manual.

Upon receipt of the application, the Radiation Safety Officer shall review it to ensure compliance with applicable license conditions, NRC regulations and Radiation Safety Committee requirements. The RSO shall be responsible for making a recommendation to the Committee Chairperson regarding approval/disapproval. Authority and responsibility for control of the irradiator must be in accordance with provisions of this manual and cannot be reassigned without the approval of the Radiation Safety Committee Chairperson. Authorizations cannot be transferred to other individuals. See the section of the manual entitled Change of Authorized Custodian.

Designated Users (operators)

Individuals may become Designated Users by completing the training requirement described in this manual and by being so designated by the Authorized Custodian. This should be recorded in Appendix A, List of Designated Users.

IRRADIATION PROCEDURES

The irradiator may be operated ONLY by:

- the Authorized Custodian (individual responsible for supervision of use, approved by the NIH Radiation Safety Committee)
- a Designated User; see Appendix A for sample form used to list Designated Users.

Users must be familiar with the operating instructions and adequately trained in proper operation and emergency procedures.

Continuous irradiation is allowed without a Designated User present ONLY after safety devices have been tested and when the restrictions on access and warning devices detailed in the section Description of Irradiator have been activated. The following safety devices must be tested prior to each unattended use:

- door interlock (B3-B44C-1)
- warning lights at entrance to B3-B44C and inside B3-B44C
- infrared motion detector inside B3-B44C
- telephone alert
- area radiation monitor in B3-B44C-1

Procedure:

(1) Obtain machine operating keys from secured location. All individuals must wear personnel dosimeters before entering the irradiator room.

(2) Visually check to make sure all persons are out of the irradiator room.

(3) Test safety devices listed above if irradiator is to be operated unattended. If any of these devices fail to operate properly do not proceed with irradiation. Secure the area and notify the Radiation Safety Branch. If safety devices operate properly continue with irradiation procedure.

(4) Place samples to be irradiated in desired geometry. If necessary, consult manufacturer's operation manual (Appendix C).

(5) Set conditions for irradiation on control console.

(6) Activate all restrictions on access and warning devices if irradiator is to be operated unattended.

(7) Begin irradiation.

(8) The source is returned to the "Beam Off" position:

(a) at the end of the predetermined time as set on the preset timer.

(b) by pushing the Emergency stop pushbutton on the control panel.

(c) by power interruption.

(9) Deactivate keyswitch and remove key.

(10) Via the TV monitor, check to see that the source rod has retracted and that the warning lights on the irradiator are no longer lit. Check warning lights outside the irradiator room. If all lights indicate the source is no longer exposed, open the door to the irradiator room and check the area monitor on the ceiling to assure safe entry. If any one monitor indicates unsafe conditions, DO NOT ENTER ROOM!! Consult Emergency Procedures.

(11) Record required data in use log (Appendix B).

(12) Return keys to secured location.

DESCRIPTION OF IRRADIATOR

Safety Systems

The room housing the cobalt-60 irradiator is posted with the appropriate radiation signs according to 10 CFR 20.203. An emergency procedure sheet is posted at the control console and at the irradiator.

Many protective devices are incorporated into the unit. The source and the source drawer will remain in the "Beam Off" position or return to the "Beam Off" position when:

(1) Electrical power supply fails.
(2) The door interlock has been activated by means of the irradiator room door being opened during irradiation or by detection of entry into the irradiator room by the infrared detector.
(3) Air pressure in the pneumatic system falls below 35 psig.
(4) An Emergency Stop pushbutton is depressed on the west wall of B3-B44C-1, either side of the main frame of the irradiator or on the control console outside the room. The Emergency Stop pushbuttons on the control console and the irradiator, when depressed, will, in addition to returning the source to a safe position, lock out all power to the main power supply. These pushbuttons must be manually reset to restore power to the console.
(5) Failure of source drawer linkage. In this event, an auxiliary source drawer retractor will return the source drawer to a safe position within 0.3 cm of the "Beam Off" position until the fault is corrected.

In addition to the protective devices described above, which are incorporated into the irradiator (some automatic), there is also a system of restrictions on access and warning devices which will allow safe operation without a Designated User in attendance. The following is a description of that system.

(1) Restrictions to the Department in General

(a) After normal working hours the entire department is locked.
(b) Housekeeping functions are performed during working hours.
(c) Access to the key to the irradiator control console is restricted to personnel who are authorized to use the irradiator and to the Radiation Safety Branch. The key to B3-B44 is not the general department key. (See Drawing 1, Position A.)

(2) Restrictions on Access and Warning Devices in Console Area (B3-B44)

(a) Warning lights- A three panel, four segment lighted warning sign is located next to the entrance door to room B3-B44C (see Figure 1). Each panel contains two incandescent bulbs wired in parallel. The panels are labelled as follows:

(i) "Cobalt-60" -- Indicates power on condition, (yellow panel).

(ii) "Safe" -- Indicates source is retracted, no radiation in the area, (green panel).

(iii) "Caution Radiation" -- Indicates source is extended, radiation in the area, (red panel). NOTE: This segment of the warning sign flashes when the source is exte ded.

(iv) Radiation Symbol -- Indicates source is extended, radiation in area, (yellow panel, magenta symbol). NOTE: This segment does not flash.

(b) TV monitor- A television monitor is located at the operator's console (see Figure 2). This is used to view the irradiator and surrounding area using a camera equipped with a wide-angle lens. The red warning light on the irradiator (which when lit indicates "Beam On") as well as the source rod can be seen with this monitor.

(c) Door to Room B3-B44C- The Entrance to Room B3-B44C is equipped with the following warning signs and access restrictions:

(i) Key lock, same key as main entrance to console area (Drawing 1, Positions A and B.)

(ii) Door has warning sign (Figure 1).

(iii) Door has combination access lock. Knowledge of combination is restricted to users of the irradiator. The combination lock is programmable and the Authorized Custodian can change it if necessary. The Radiation Safety Branch will be notified of combination changes.

(3) Restrictions on Access and Warning Devices in Room B3-B44C

(a) Warning Lights- These warning lights are the same design as those described in Section (2)(a). They are located on the west wall, directly across from the entrance door (see Figure 3). They are wired in parallel with the other warning signs.

(b) Intrusion Detector- A passive infrared motion detector is mounted on the west wall, facing the room entrance. This detector is activated while the beam is on and issues a verbal warning when entry is sensed. The warning statement issued is: "WARNING, YOU ARE ENTERING A SECURE AREA. PLEASE EXIT IMMEDIATELY." This warning is issued twice, after which the detector is reset.

(c) The shielded door is the only entrance to the irradiator room and is posted with a "Caution High Radiation Area" warning sign (see Figure 4). The door is equipped with an interlock switch which is in series with the circuit energizing the source to the "Beam On" position. The door must be closed (contact made between door and interlock switch) before the source can be placed in the "Beam On" position. If the door is opened while the source is in the "Beam On" position, the interlock circuit is broken and the source will retract to its shielded position. Once the door interlock is tripped, the irradiator must be manually reset at the console to resume irradiation.

(4) Restrictions and Warning Devices in the Irradiation Room(B3-B44C-1)

The entrance into the irradiator room opens into a corridor that is shielded from primary radiation. The radiation levels in this corridor are substantially lower than those in the room proper. Warning indicators are arranged to be viewed while in this corridor.

(a) Warning Lights- These warning lights are the same as those described in Section (2)(a). These lights are on the north wall, facing the entrance (see Figure 5). They are wired in parallel with the other warning lights.

(b) Independent Radiation Monitor- An area radiation monitor is mounted on the ceiling and is visible from the room entrance (see Drawing 1 and Figures 5 and 6). Power supply to the monitor is connected to the hospital emergency power system so that the monitor will continue to function in the event of a power failure. This monitor provides a visual indication of a radiation hazard, using a flashing red light, and an audible warning tone if the door is opened while the

source is on. The monitor will alarm at ≥ 2 mR/hour. This alarm is calibrated annually.

(c) Intrusion Detector- A passive infrared sensor is mounted on the north wall facing the entrance (see Drawing 1 and Figure 5). This detector is wired in series with the door interlock circuit and will activate this interlock when entry is detected. Power to this sensor is also on the hospital emergency power supply so that it will continue to operate in the event of a power failure.

(5) Alerts to the Authorized Custodian or Designated User

(a) Telephone Alert System- A status monitor alarm is installed to monitor several conditions and alert the Authorized Custodian or Designated User to potential problems by a telephone message. The Authorized Custodian or Designated User is responsible for informing the Radiation Safety Branch if the telephone alert system has been activated and a radiation hazard exists. Location of this device is shown in Drawing 1 and Figures 1, 2 and 7. The following conditions are sensed by the telephone alert system:

(i) Irradiation interrupted
(ii) Temperature in irradiator room out of set limits
(iii) Electrical power failure

Upon sensing any of the above conditions, a telephone alert cycle is activated. The alert can be placed to several different telephone numbers in rotary fashion. When a phone is answered, the device issues a verbal status report. The device must then be deactivated by a return phone call or the alert cycle will continue. In addition, the device can be called at any time to obtain a status report. This device is also equipped with battery back-up so that it will continue to function in the event of a power failure.

During periods of irradiation without a designated user present either the Authorized Custodian or a Designated User is required to be available to respond to a telephone alert. If a radiation hazard exists (i.e., fire) the actions outlined in the section Emergency Procedures must be taken. The Radiation Safety Branch must be notified as soon as possible.

Any changes in the above described system of restrictions on access and warning devices must have prior approval of the Chairperson, Radiation Safety Committee.

All entry controls will be tested quarterly by the Radiation Safety Branch. If entry controls are not functioning properly the irradiator will be taken out of service immediately and the defective control repaired or replaced.

A use log is to be maintained by the Authorized Custodian and should be available for inspection by the Radiation Safety Branch staff. The use log should record the information requested in Appendix B, Use Log, along with information concerning maintenance, relocation, change of Authorized Custodian, removal and leak tests.

A copy of this document, Radiation Safety Procedures Manual For Operation of Irradiator (Eldorado 78), and the manufacturer's operations manual shall be located at the control panel for review during use of irradiator by Designated Users.

Refer to Appendix C, Specifications, Eldorado 78 Teletherapy Unit, for additional information on the irradiator and operating procedures.

RELOCATION

Relocation of this irradiator is not permitted unless approval has been obtained from the NRC. If such action is contemplated, contact the RSO at least 3 months in advance to enable appropriate actions to be taken, e.g., submission of an application to the NRC.

CHANGE OF AUTHORIZED CUSTODIAN

If transfer of responsibility for the irradiator is contemplated, the new user must apply for authorization to the Chairperson, Radiation Safety Committee. The application is to be routed through the Radiation Safety Officer (RSO) who shall review it to insure compliance with applicable license conditions, NRC regulations, and Radiation Safety Committee requirements. The RSO shall be responsible for making a recommendation to the Committee Chairperson regarding approval/disapproval. Authority for and responsibility for control of the irradiator must be in accordance with provisions of this manual and cannot be reassigned without the approval of the Radiation Safety Committee Chairperson. See also the section of this manual, Procedures for Gaining Authorization to Use Irradiator.

REMOVAL

If removal or decommissioning of the irradiator is contemplated, contact the RSO. The irradiator can only be transferred to another appropriately licensed institution or individual; in the event that the sealed source is to be disposed, the manufacturer or others who are appropriately licensed must be involved in its removal and disposition.

MAINTENANCE

In the event of malfunction of the irradiator, the Authorized Custodian shall be responsible for notifying the RSO.

Under no conditions shall operators or the Authorized Custodian attempt to : (a) repair or modify source positioning mechanisms or shutters, interlocks, shielding or other systems designed to maintain the irradiator in a safe condition; (b) attempt to gain access to or remove the sealed sources.

Source replacement shall be performed by the manufacturer or other duly licensed entity.

If maintenance of the above type is contemplated, the Authorized Custodian shall be responsible for notifying the RSO so that the necessary inspections and safety procedures can be performed.

OTHER SAFETY PROCEDURES

Leak Tests

The Radiation Safety Officer will be responsible for insuring that leak tests are performed. To insure the integrity of the sealed source, tests will be performed by Radiation Safety Branch staff at intervals not to exceed 6 months. Paper swipes or cotton swabs are used to wipe accessible surfaces of the irradiator where contamination might be expected if the source is leaking. The samples will be counted in a detection instrument capable of quantitatively measuring 0.005 microcurie or more activity. Any leak test indicating greater than 0.005 microcurie of removable contamination shall result in the immediate removal from service of the irradiator. Notification will be made to appropriate authorities as required by NRC regulations. The performance of a leak test shall be recorded in the Use Log (Appendix B).

Routine Compliance Surveys

The RSO will be responsible for insuring that the following surveys are performed quarterly:

(1) Insure proper operation of all interlocks on irradiator.
(2) Measure exposure rates at all accessible points around the irradiator using a portable ionization chamber and insure that levels are within regulatory limits.
(3) Checks for compliance with provisions of this manual including adherence to Irradiation Procedures and proper training of operators.
(4) Verify that the area radiation monitor will alarm at $\geq$ 2 mR/hour.
(5) Document completion of survey in the Use Log (Appendix B).

TRAINING REQUIREMENTS

Training for the Authorized Custodian will include:

(1) Attendance at the course, "Radiation Safety in the Laboratory", presented by the Radiation Safety Branch.
A schedule for this course is shown on the next page.

(2) Irradiator safety training provided by the Radiation Safety Branch to consist of at least the following:
   (a) Contents of this manual.
   (b) Demonstration of the proper operation of the irradiator. This will include instructions for testing safety devices before each unattended operation as described in the section Irradiation Procedures.
   (c) Emergency procedures.

Training for Designated Users will include:

(1) Designated Users (operators) are required to complete the above program. The Authorized Custodian of the irradiator will be responsible for accomplishing item 2.

(2) The Authorized Custodian will enter the name of each Designated User on the List of Designated Users (Appendix A), note the date of his/her training, and sign the form to certify that the Designated User has been properly trained.

RESPONSIBILITIES

Authorized Custodian

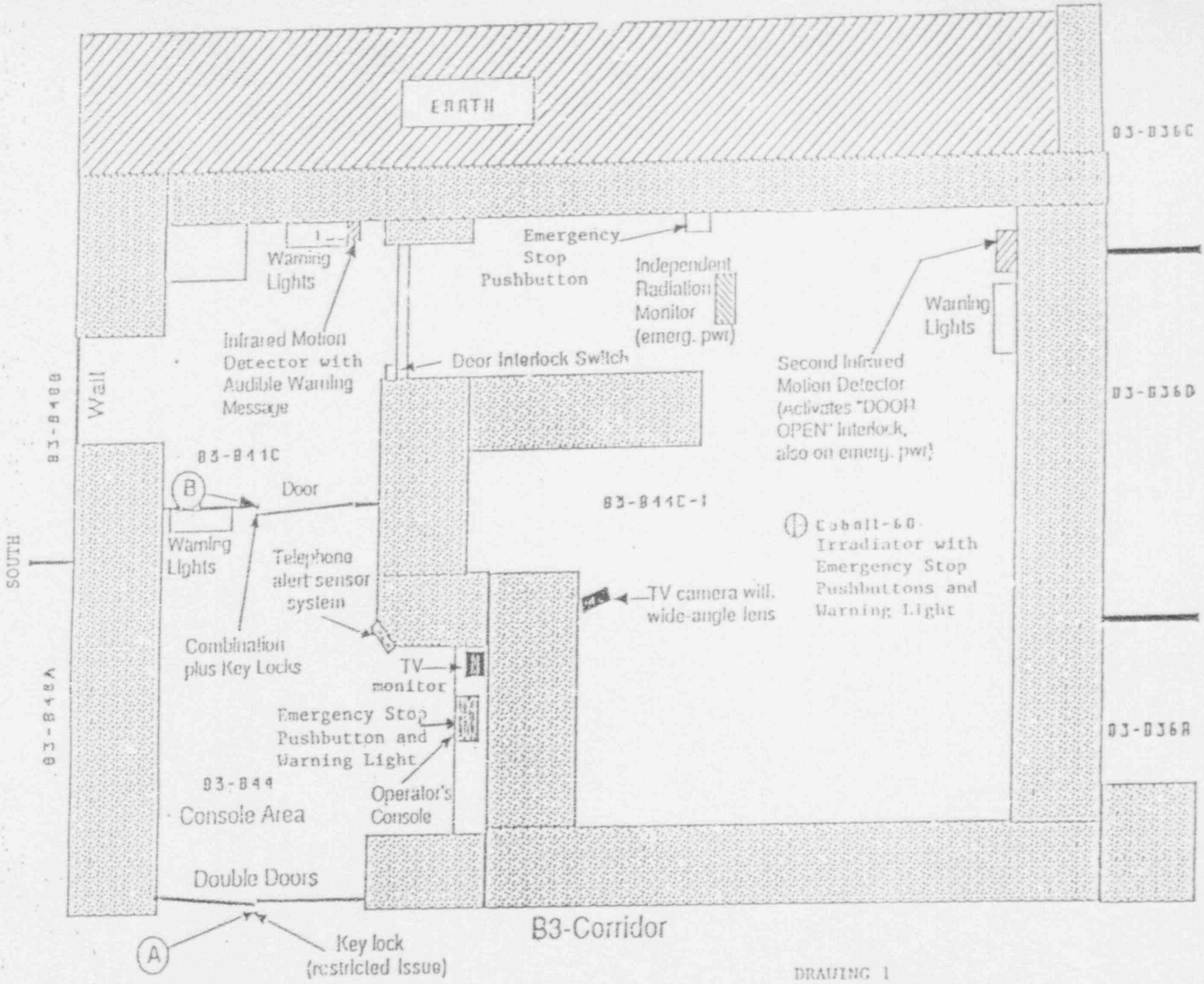
(1) Maintain the irradiator in a clean and mechanically functional condition.
(2) Notify the Radiation Safety Branch of any anticipated changes in configuration, location, or operation in a timely manner (see applicable sections of this manual).
(3) Insure that Designated Users receive training as required and wear personnel monitoring devices when using the irradiator.
(4) Insure that the irradiator is operated in accordance with this manual.
(5) List and certify Designated Users in Appendix A to this manual.
(6) Insure physical security of the key to the irradiator.
(7) Notify the Radiation Safety Branch immediately of any malfunctions or problems with the irradiator (see Emergency Procedures section of this manual).
(8) Arrange for repairs or maintenance of the irradiator by appropriate persons (see Maintenance section of this manual).

Designated User

(1) Operate the unit in accordance with this manual at all times and wear personnel monitoring device when using irradiator.
(2) Notify the Authorized Custodian immediately of any malfunctions or other problems with the irradiator.
(3) Insure that the key is returned to secure storage following use of the irradiator.

Radiation Safety Branch

(1) Maintain irradiator license.
(2) Conduct leak tests as described in this manual.
(3) Provide training as described in this manual.
(4) Conduct inspections as stated in Other Safety Procedures section of manual.
(5) Provide personnel monitoring devices to irradiator users.



DRAWING 1

NIH Building 10

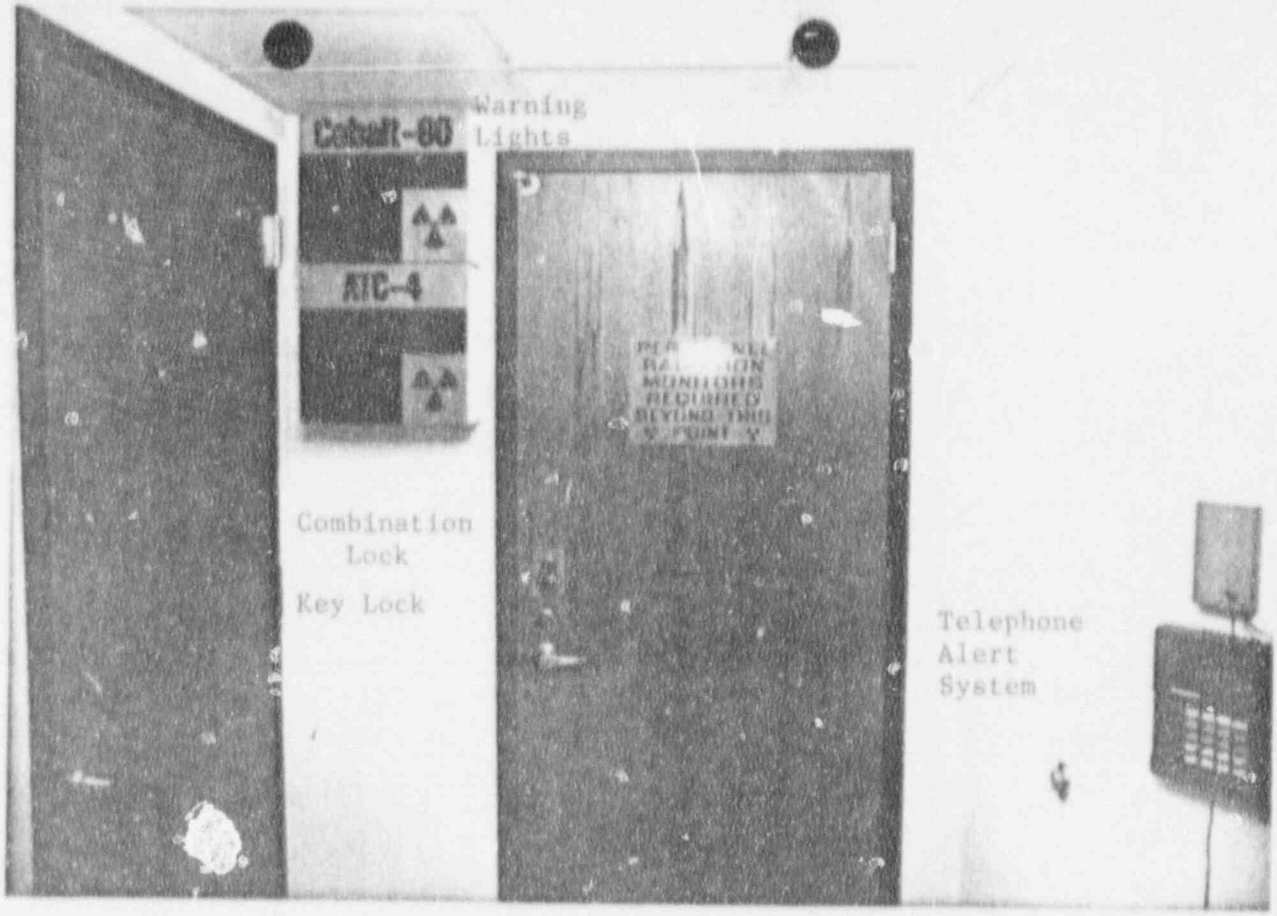


FIGURE 1 Door leading to B3-B44C

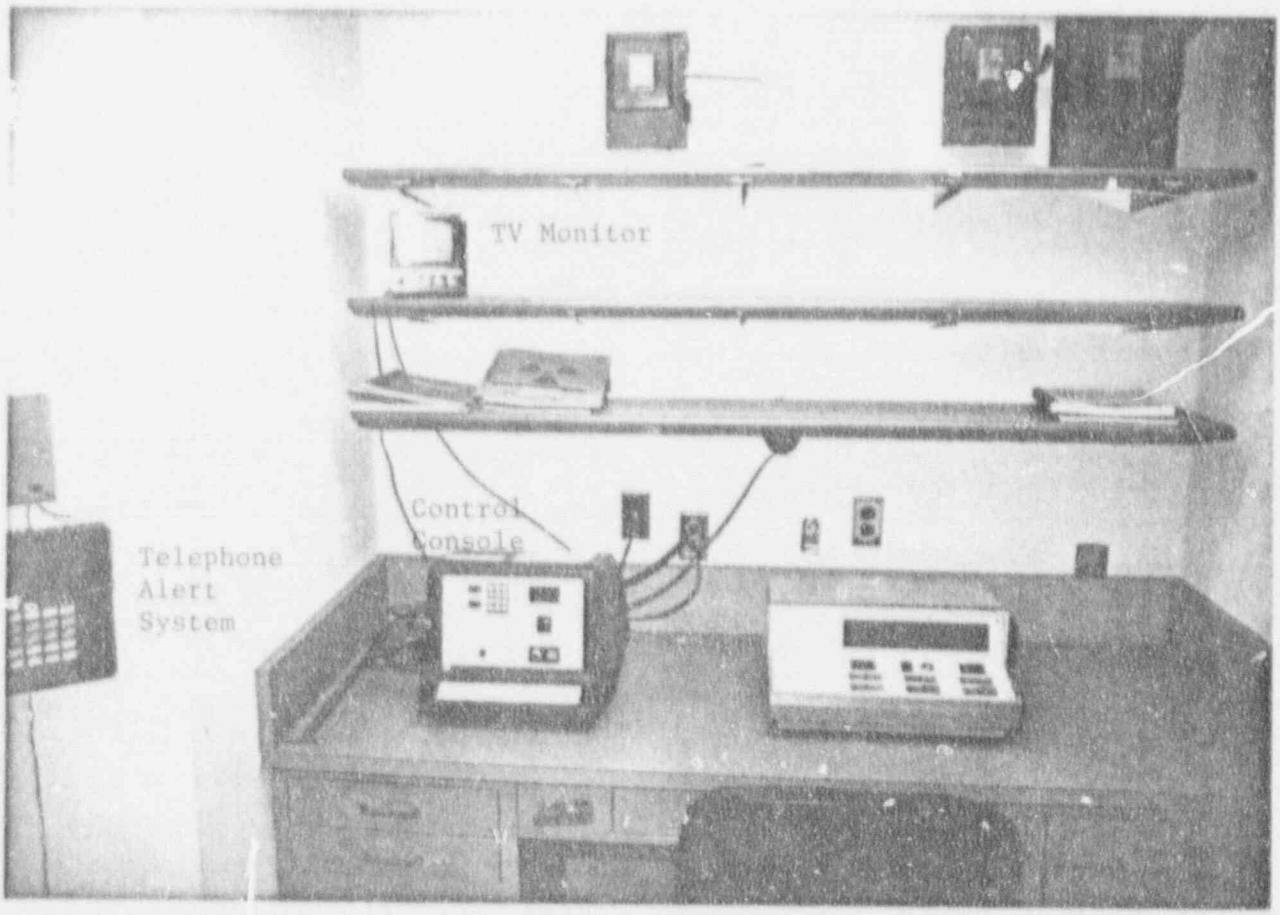


FIGURE 2 B3-B44

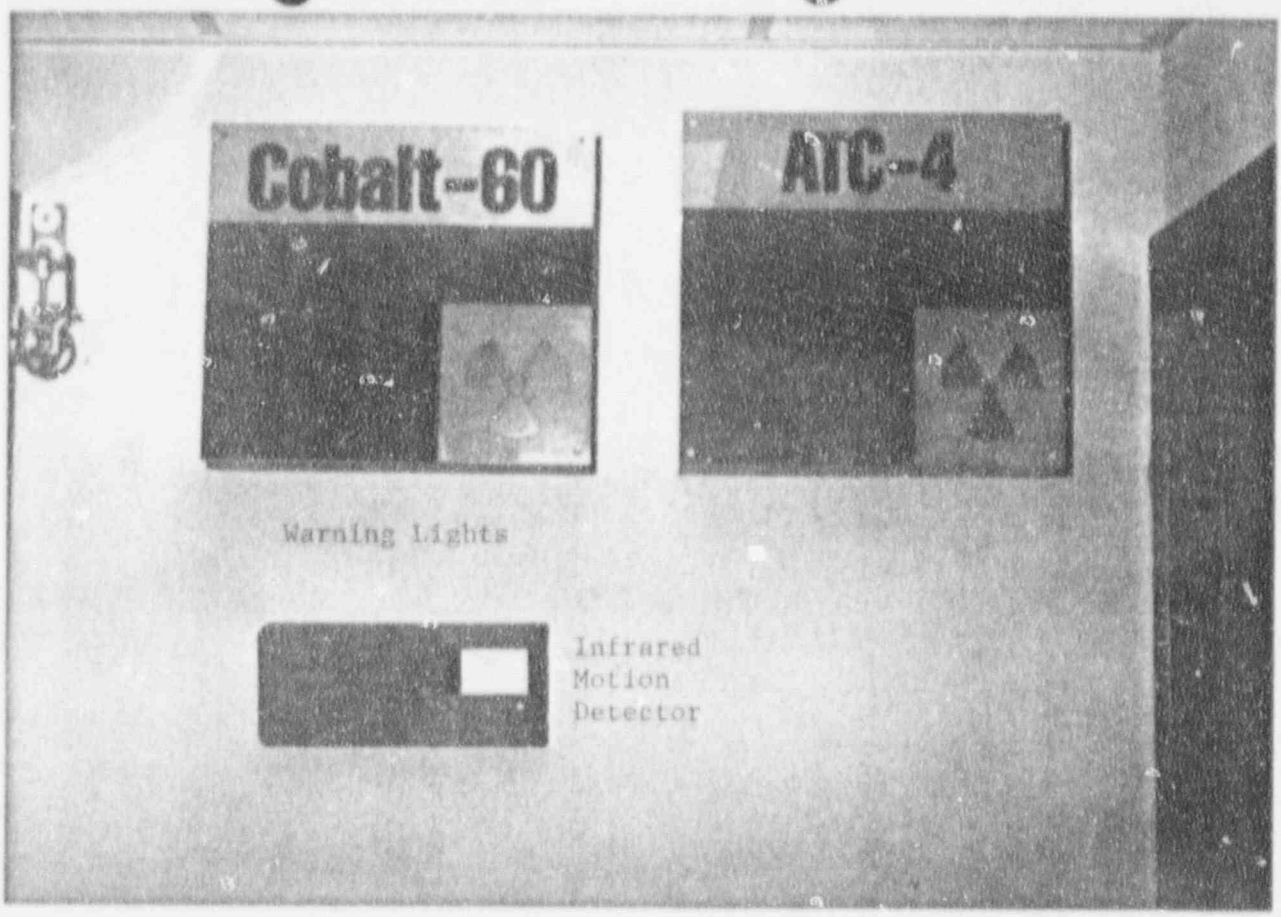


FIGURE 3 West wall of B3-B44C

FIGURE 4 Door to B3-B44C-1

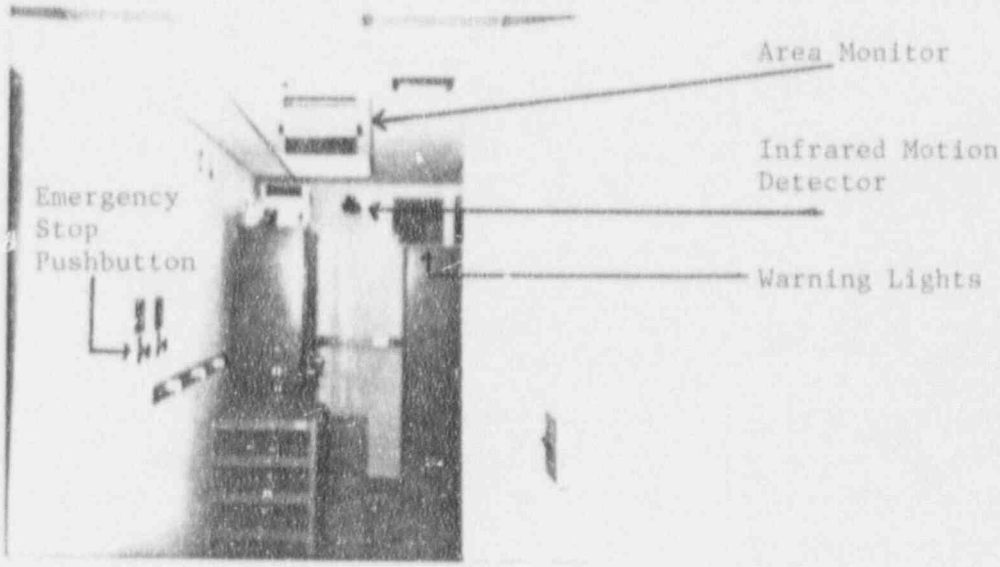
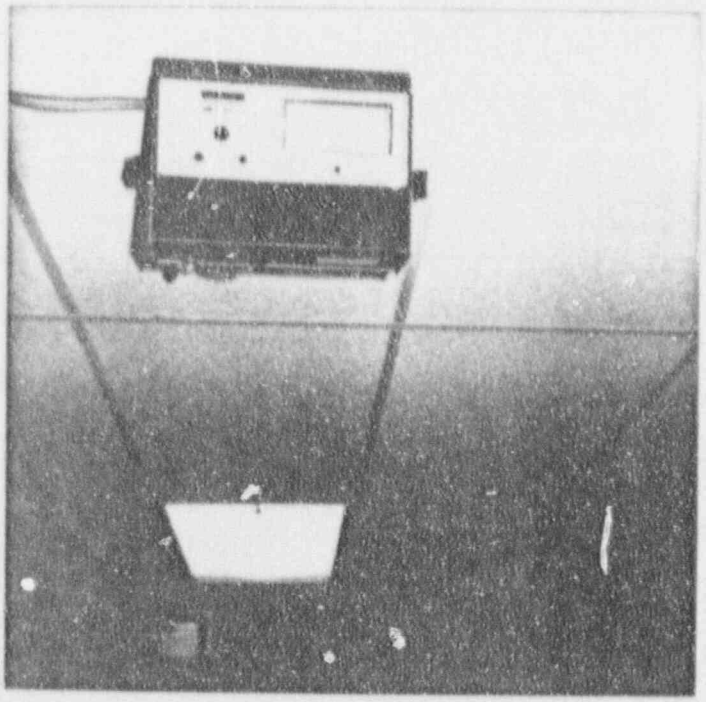


FIGURE 5 B3-B44C-1 Entrance

FIGURE 6 Ceiling of B3-B44C-1



Area Monitor

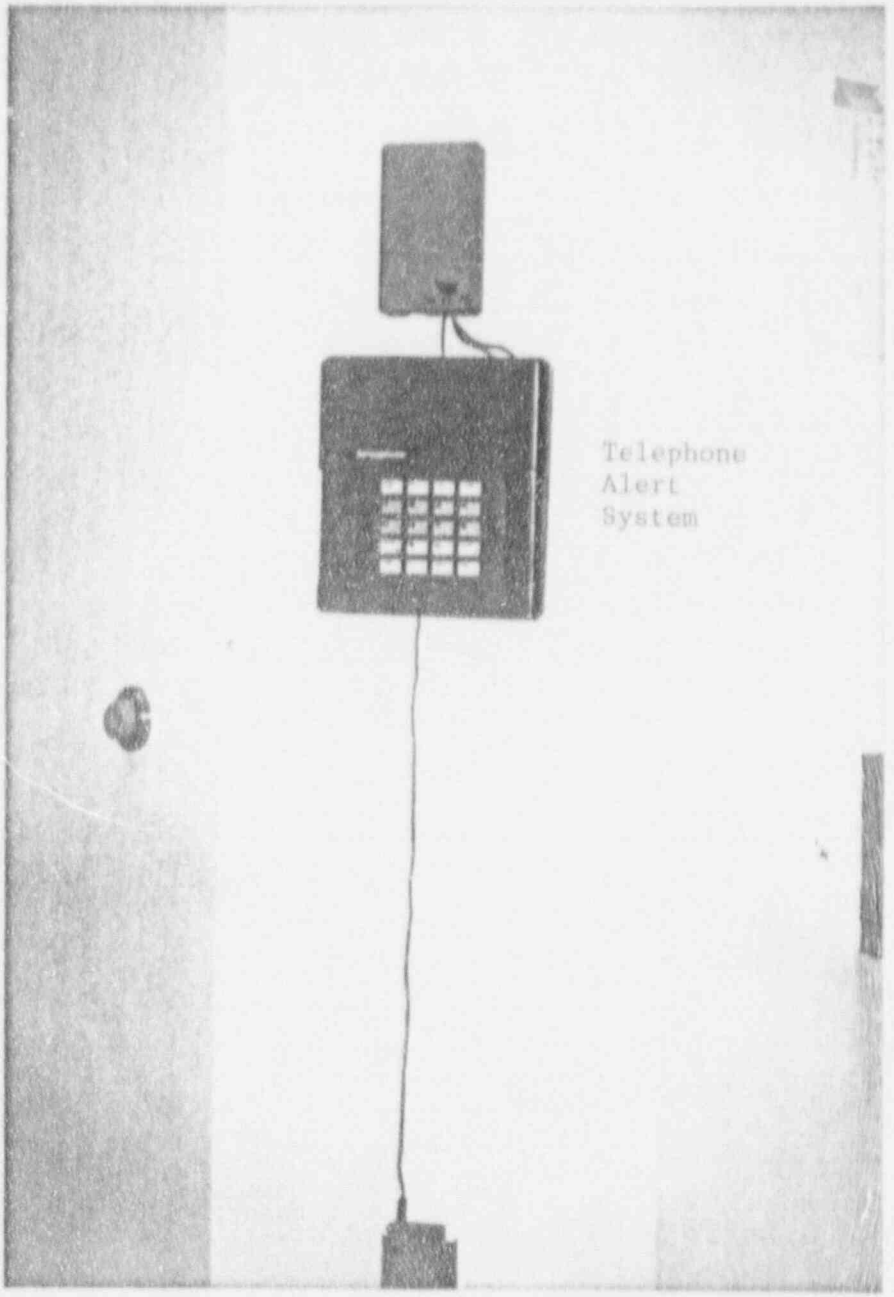


FIGURE 7 B3-B44

APPENDIX A

DESIGNATED USERS OF THIS IRRADIATOR

ONLY THE FOLLOWING INDIVIDUALS ARE PERMITTED TO OPERATE THIS UNIT

NAME OF DESIGNATED USER	DESIGNATED USER'S RADIATION SAFFTY REGISTRATION NUMBER	DATE APPROVED AND CERTIFIED BY AUTHORIZED USER	SIGNATURE OF AUTHORIZED USER

APPENDIX B

IRRADIATOR USE LOG

NOTE:
1. THIS IRRADIATOR MAY BE OPERATED ONLY BY DESIGNATED USERS APPROVED BY THE AUTHORIZED USER.
2. THIS LOG MUST BE COMPLETED EACH TIME THIS IRRADIATOR IS USED.
3. WRITE ANY COMMENTS OR NOTE ANY ABNORMAL OPERATING CONDITIONS ON THE LINE FOLLOWING YOUR USE ENTRY.

NAME OF USER (PRINT NAME)	RADIATION SAFETY NUMBER	PROCEDURE CONDUCTED/ ITEM IRRADIATED	START TIME/DATE	STOP TIME/DATE

NUMBER C81008
MAY 1, 1977

ELDORADO 78 TELETHERAPY UNIT

A. GENERAL

The Eldorado 78 Cobalt-60 Teletherapy Unit is designed for fixed field techniques. The sourcehead capacity of the unit is guaranteed at a minimum of 125 Rmm - ICRU* (maximum 67 Ci/Rmm - ICRU). However, for those units ordered with an AECL Cobalt-60 source with output exceeding 125 Rmm - ICRU, the unit will be provided with a guaranteed minimum capacity of 200 Rmm - ICRU, at no additional charge. The unit complies with the recommendations of ICRP-15.

**Measured according to the International Commission on Radiation Units and Measurements Report No. 18.*

The unit consists of the following basic component parts:-

- Sourcehead
- Collimator Assembly
- Base and Main Frame
- Controls
- Radiation Source (see Section C - NOTE)

B. COMPONENT PARTS

B.1 Sourcehead

The sourcehead consists of a lead and depleted uranium shield encased in a cast steel shell, and a source drawer using a pneumatic drive system to move the source between the ON and OFF positions.

a) The source is mounted in a brass-encased lead source drawer. The source drawer slides within the sourcehead and is a principal part of of the Beam Control System. The source drawer also fits into the standard AECL shipping and transfer container from which it can be readily loaded into, or removed from the sourcehead. The sourcehead can also be used as a shipping container. Source drawers are interchangeable between Theratron 780/765, Eldorado 78/76, and their predecessors the Theratron 80/60 and Eldorado 8/6.

b) A compressed air driven piston moves the source drawer system between the BEAM ON and BEAM OFF positions. Accurate positioning of the source is ensured by guide pins at the BEAM ON and BEAM OFF positions.

c) The pneumatically operated system ensures that the source is moved to the BEAM OFF position at completion of the treatment period or in the event of a number of unsafe situations (see Section D).

d) Sourcehead swivel is provided through 360°. A scale which can be read from both sides of the unit indicates the angle of rotation from 0° to 359°. Travel time for 360° of swivel is approximately 2.5 minutes. When the central axis of the beam is pointing down, the scale reading is 180°.

e) A panel containing indicator lamps and illuminated switches is located on the front of the sourcehead (see Section E.4.2).

f) The face of the source may be positioned anywhere between 76 cm and 206 cm above the finished floor.

g) Provision is made on both sides of the sourcehead for mounting a Pin and Arc Localizer, a Mechanical Backpointer, or a Treatment Distance Indicator.

B.2 Collimator Assembly

Beam collimation is provided by an adjustable collimator mounted within the sourcehead. The collimator consists of a depleted uranium fixed shield; two pairs of motorized, continuously adjustable, intermeshing lead leaves called primary definers, hinged to the fixed shield; and two pairs of depleted uranium trimmer bars fixed to the

rimary definers at 45 cm SDD to serve as secondary definers. Additional removable trimmers are available as accessories, one set to mount at 55 cm SDD, and another to mount at 65 cm SDD.

B.2.1 Field Sizes

The continuously adjustable definers will give fields as per the table below:

FIELD SIZE RANGE AT 80 CM SID		
SDD	Minimum (cm)	Maximum (cm)
45	5.0	38.0
55	4.5	34.0
65	3.5	33.0

The primary definers are hinged near the source and are set so that at maximum field size, the face of the definer is on a line drawn from the edge of the source to the maximum field size at 80 cm from the source face. The hinge points are factory adjusted to suit different source diameters.

The size of the radiation field is measured on the 50% geometric pneumbra line at 80 cm from the face of the source. The field size for each SDD is displayed digitally at the front of the collimator when the SDD is selected by the Trimmer Factor Selector located near the readout.

B.2.2 Field Localizing System

The Field Localizing System consists of a high intensity, long-life, quartz-halogen light bulb, mounted on the end of the source drawer so that the light shines through the collimator when the source is in the OFF position. The radiation field set by the collimator can thus be visually confirmed. The centre of the field is marked by the projection of crosswires which are located in the collimator. The light is controlled by means of an illuminating pushbutton switch (FIELD) located on the head cover.

B.2.3 Field Accuracy

Accuracy of bulb alignment is such that the crosswires are projected to within ±1 mm at the beam centre, defined as the axis of collimator rotation at 80 cm from the source. Variation between the optical field, the radiation field, and the field size readout does not exceed ±2.5 mm at 80 cm from the source.

B.2.4 Collimator Rotation

The collimator will rotate around the central axis of the beam through an angle of ±150°. Minimum time for 360° rotation is approximately 45 seconds. With the aperture facing the front of the unit the centre point of collimator rotation is 180°.

B.2.5 Optical Treatment Distance Indicator

An Optical Treatment Distance Indicator is provided with a scale range of 55 cm to 100 cm source-to-skin distance (SSD). This is controlled from the collimator control panel.

B.2.6 Collimator

The collimator is equipped with an extendable rail mechanism. These rails are equipped to accept wedge filters and beam shaping blocks at the same time. They are adjustable to allow 45 cm, 55 cm, or 65 cm wedges to be used.

B.2.7 Collimator Control Panel

A Control Panel is mounted on the front of the collimator (see Section B.4.3).

B.3 Base and Main Frame

B.3.1 Base

The unit is supplied with a welded structural steel base. The base mounts in a pit in the treatment room floor and, once aligned, can be cemented in position enabling the whole unit to be rigidly mounted. Other mounting methods are possible if the floor is too thin or weak to support the base.

B.3.2 Main Frame

The main frame, which is mounted on the base, supports the sourcehead vertical drive components, the main electrical panel, and an air compressor.

Service access to the mechanical and electrical components within the main frame is through removable panels at the rear of the main frame.

B.3.3 Carriage Assembly

The sourcehead is mounted on a carriage assembly which rides on tracks machined on the vertical main frame structure.

B.4 Control System

The Control System comprises a Set Up Control located in the treatment room, various displays and switches on the unit, and a treatment console located outside the room.

B.4.1 Unit Mounted Controls

An EMERGENCY STOP pushbutton is located on each side of the main frame (see Section D).

B.4.2 Sourcehead Mounted Controls

On a panel mounted on the sourcehead are the following:-

a) A thumbwheel control which governs the speed and direction of collimator rotation.

b) Two lights indicating BEAM OFF and BEAM ON

c) A light to indicate if the beam is OFF SHIELD.

d) An illuminating pushbutton which controls the field light.

B.4.3 Collimator Mounted Controls

A panel on the front of the collimator contains the following:-

a) Two digital displays for indicating field size.

b) A trimmer factor selector. A three-position switch, which is used to alter both digital displays of field size to read correctly when 55 cm or 65 cm trimmers are attached.

c) Controls which govern the speed and direction of collimator leaves.

d) An Optical Distance Indicator pushbutton.

B.4.4 Set-Up Control

A portable Set-Up Control is stored on the side of the unit. It is connected to the main frame assembly by means of a flexible cable.

The Control includes the following:-

a) EMERGENCY STOP - a red pushbutton. (See Section D.)

b) HEAD SWIVEL - A pushbutton switch controlling head swivel motion.

c) HEAD VERT - A pushbutton switch controlling head vertical motion.

B.4.5 Treatment Console

The Treatment Console contains the following:-

a) A key-operated, three-position POWER switch marked OFF, ON, and START which controls electrical power to the unit.

b) A yellow RESET indicator lamp and pushbutton. This lamp will illuminate when the controls are incorrectly set or when an unsafe situation exists (see Section D). The operator must correct the situation and depress the button before treatment can be started.

c) Circuit breaker - push to reset type.

d) Indicator Lamps:-

- BEAM OFF (Green)
- BEAM ON (Red)

e) EMERGENCY STOP pushbutton (Red). (See Section D.)

f) TREATMENT TIMER - A synchronous timer having a range of 0 to 55 minutes, calibrated in minutes and hundredths of a minute, complete with a pushbutton marked TREAT and OFF.

NOTE: A spare printed circuit board Kit is included (G22-158C).

C. RADIATION SPECIFICATIONS & SOURCES

a) The Eldorado 78 meets the recommendations of the International Commission on Radiological Protection, ICRP Publication 15, paragraph 139 "Teletherapy Protective Source Housing" and National Council on Radiation Protection and Measurements Report No. 33 and No. 34 (NCRP 33 and 34).

b) The actual collimator does not exceed 1% transmission of the useful beam exposure rate, compared to the 2% maximum allowed in recommendations contained in ICRP 15.

The Cobalt-60 radiation sources supplied by AECL are doubly encapsulated in stainless steel and are measured in a measurement cell to the standards laid out in the International Commission of Radiation Units and Measurements (ICRU Report No. 18), filled to the output ordered with a filling tolerance of ±10%. A Measurement Certificate is provided with each source.

NOTE: All references to "Rmin" contained in this specification are based on recommendations contained in ICRU 18.

c) The sources are mounted in source drawers which are interchangeable between Theratron 780/765, Eldorado 78/76, and their predecessors, the Theratron 80/60 and Eldorado 8/6.

D. PROTECTIVE DEVICES

The following protective devices are incorporated in the unit:-

The radiation source and the source drawer will remain in the BEAM OFF position or return to the BEAM OFF position under the following conditions:-

a) Electrical power supply failure.

b) When the door interlock, which must be supplied by the customer, has been activated by means of the treatment room door being opened during treatment.

c) Air pressure in the pneumatic system falls below 35 psig.

d) An EMERGENCY STOP pushbutton is depressed on either side of Irradiator Main Frame or on control console outside of Irradiator room.
This will stop the unit, retract the source, and trigger two audible alarm systems:-

- a buzzer on the main frame relay panel inside the treatment room, and
- an alarm at the Treatment Console outside the treatment room.

The EMERGENCY STOP pushbuttons, located on the sides of the Main Frame, when depressed, will, in addition to returning the source to a safe position, LOCK OUT all power to the Main Power Supply. These pushbuttons must be manually reset to restore power to the console.

e) The source drawer linkage fails. In this event an auxiliary source drawer retractor will return the source drawer to a safe position within 0.3 cm of the BEAM OFF position at the end of treatment. The source will then remain in the BEAM OFF position until the fault is corrected.

NOTE: In the highly unlikely event that the pneumatic system or the auxiliary source drawer retractor should fail, the source drawer may also be returned to a safe position manually. A T-bar is supplied for this purpose.

[redacted]

E. APPEARANCE

E.1 Colour

Standard AECL colours of brown and beige.

E.2 Covers

Moulded ABS covers are provied for the sourcehead. Sheet metal covers are provided for the main frame.

F. WEIGHTS & DIMENSIONS

F.1 Basic Unit

Weight - 3,000 kg (6,600 lb) estimated.

Projected Floor Area - 2.48 sq.m (26.4 sq.ft).

Floor Loading - 1,220 kg/sq.m (250 lb/sq.ft).

F.2 Overall Unit Dimensions

Length - 240 cm (94.5 in).

Height - 270 cm (106.3 in) above the finished floor.

Width - 70 cm (27.5 in) across main frame.

F.3 Floor Pit Dimensions

Length - 259 cm (102 in).

Depth - 21.6 cm (8.5 in).

Width - 122 cm (48 in).

G. POWER REQUIREMENTS

Electrical power required is 208 or 220 Vac, three-phase, 2.5 kVA, 50 or 60 Hz. Frequency and voltage must be specified by the customer at time of order. The Unit is approved by the Canadian Standards Association (C.S.A.).

H. OPTIONS

H. Wedge Filter Interlock System (G22-179D)

A factory installed option which reduces the risk of a misstreatment with the wrong wedge. Treatment is not possible until a thumbwheel switch on the collimator has been set to a number which agrees with the number of the wedge inserted into the collimator rails. Each wedge is coded by the addition of a metal actuator. If the unit is used without wedges, the thumbwheel switch must be set at zero. If a coded wedge is inserted when the switch is at zero, treatment is prevented. A warning light indicates that the switch setting does not agree with the wedge coding. Wedges to be used with this option must be modified per G22-197E.

NOTE: The system can accommodate up to 27 wedges (9 at 45 cm, 9 at 55 cm, and 9 at 65 cm SSD).

I. ACCESSORIES

I.1 Accessories Provided with Unit at No Charge

~~Mechanical Treatment Distance Indicator (50 to 100 cm) (G22-097A)~~

~~This device is used to indicate the source to skin distance from 50 to 100 cm SSD.~~

Isodose Charts (G20-010)

The following set of approximately 140 isodose charts for fixed field techniques is supplied with each unit, provided an AECL Cobalt-60 source is purchased with the unit. Charts are provided on white opaque, shrink-proof paper.

1.00 cm diameter	(17 charts)
1.25 cm diameter	(5 charts)
1.50 cm diameter	(79 charts)
1.75 cm diameter	(8 charts)
2.00 cm diameter	(32 charts)

I.2 Beam Modifying Accessories

Trimmer Bars - 55 cm SDD (G20-092A)

A set of 4 removable trimmer bars. Material - unalloyed, depleted uranium. Weight - 8 kg per set.

Trimmer Bars - 65 cm SDD (G22-092A)

A set of 4 removable trimmer bars. Material - unalloyed depleted uranium. Weight - 9 kg per set.

BEAM SHAPING TRAY Kit (G22-097E)

The Beam Shaping tray slides into the collimator rails, and can be positioned anywhere between 54 cm and 71 cm from the source. A set of 21 lead beam shaping blocks is provided. The blocks can be mounted above or below this tray. The tray can be turned over with the blocks attached and the rails adjusted for A & P treatments. Maximum load of blocks is 14 kg. Wedge filters can be used at the same time as the blocks. The kit includes a tray with holes and a tray without.

Beam Shaping Tray (G22-150C)

An aluminum tray with an array of holes enabling the lead beam shaping blocks (G22-229) to be attached. (Part of G22-097E).

Beam Shaping Tray - Plain (G22-150B).

An acrylic tray which can be used when the unit is in the vertical position only. (Part of G22-097E).

Beam Shaping Blocks - Lead (G22-229)

An assortment of 21 lead blocks which can be individually clamped to the aluminum tray (part of Beam Shaping Tray Kit G22-097E).

am Shaping Blocks (Set of 7) - Uranium (G10-149)

ese can be used with G22-097E in vertical posi-
n only, or with G21-105.

am Shaping Tray - Mobile (G21-105)

his mobile table is used to position a set of beam
aping blocks over the patient on the stretcher.
e tray can be used above or below the stretcher
d will support a weight of 23.0 kg. The tray can
positioned anywhere between 127 cm and 97
above the floor.

edge Filters

° wedges (set of three for use at 45 cm SDD)*
22-151)

° wedges (set of three for use at 55 cm SDD)*
22-174)

° wedges (set of three for use at 65 cm SDD)*
320-151)

wedges (set of three for use at 45 cm SDD)*
22-152)

5° wedges (set of three for use at 55 cm SDD)*
322-175)

5° wedges (set of three for use at 65 cm SDD)*
320-152)

0° wedges (set of three for use at 45 cm SDD)*
322-153)

0° wedges (set of three for use at 55 cm SDD)*
G22-176)

0° wedges (set of three for use at 65 cm SDD)*
G22-153)

*In this context "45, 55, and 65 cm SDD" means that
he wedges are mounted below the 45 cm defining distance
r the 55 cm and 65 cm trimmers.*

Each set is supplied with 12 isodose charts.

NOTE: If the Wedge Filter Interlock System (G22-179D) is purchased, all wedges which are to be used with the system must be modified as per G22-179E.

fications for Wedge Filters (G22-179E)

Modification of wedges for use with G22-179D
sets of 3 wedges).

Wedge Filter Storage Cabinet (G22-173)

This cabinet will hold up to 18 AECL wedge filters (wedges are not included).

Breast Treatment Trimmer (G22-207A)

This collimator mounted device is used in the treatment of the breast, where maximum trimming is required. The trimmer attaches to one of the lower collimator leaves and weighs only 3.6 kg. Instructions and an isodose chart are included.

Breast Treatment Set-Up Device (G22-207B)

This device attaches to one of the lower collimator leaves and provides trimming to 65 cm SDD. It includes a removable polycarbonate frame used to align the patient with the beam.

Small Field Cones (G22-167)

A set of four cones for use at 45 or 55 cm* SDD. Approximate field sizes (when cones are mounted at 55 cm) are:-

2 cm square at 80 cm SSD
3 cm square at 80 cm SSD
2 cm diameter at 80 cm SSD
3 cm diameter at 80 cm SSD

A 55 cm SDD Isodose Chart is provided for each cone.

**At 55 cm SDD, 55 cm SDD trimmers (G20-092A) are required.*

1.3 Beam Positioning Accessories

Mechanical Backpointer (G22-022)

This accessory is used to indicate the centre of the emergent beam after passage through the patient.

Pin & Arc Localizer - 0° to 90° (G22-024)

Based on the original Manchester design, the Pin & Arc is used to align the centre of the tumour with the beam centre line when the tumour depth is known for some angle other than the treatment angle.

Wall or Ceiling Mounted Positioning Light (G9-055)

Designed for mounting on the wall or ceiling of the treatment room, the positioning light projects a beam of light onto the patient's skin permitting the patient to be aligned with the beam axis. The Wall Lights are designed so that the light beam can be

adjusted 45° from either side of centre. The lights, which are sold singly, are also equipped with their own transformer and line cord which can be connected to any convenient 110 or 230 Vac supply.

Isovigilant Laser (G22-227A)

Single IL900 laser with reflective interlock which can be used to stop treatment should the patient move.

Isovigilant Laser System (G22-240A)

Consists of three isovigilant line/spot lasers, a single sagittal plane line laser and a remote control console. Used to monitor patient movement during treatment. Can be interlocked with the unit to stop treatment if the patient moves.

1.4 Control & Patient Comfort Accessories

Teletherapy Room Monitor (G9-135)

The teletherapy room monitor is a wall-mounted radiation warning device for use in a beam therapy treatment room. (It can also be used with other types of high energy equipment.) The two-part device consists of a monitor which is wall mounted inside the treatment room and a remote warning device, also wall-mounted, outside the treatment room. When the radiation field exceeds a predetermined level of 15 mR/hr ± 5 mR/hr at the monitor position, a three-way warning system is activated:-

- A red warning light on the monitor is illuminated;
- A red lamp on the remote warning device is activated at 0.5 second intervals.
- An audible alarm is electrically connected through a separate customer-supplied 12 V dc treatment room door interlock switch to the monitor unit, and functions only in the event of the door being opened while a high radiation field exists. The monitor automatically shuts itself off when the radition level returns to the predetermined level, 15 mR/hr ± 5 mR/hr.

Power required is 115 V ac, 50/60 Hz, 25 W. A continuously charged battery automatically provides power for a minimum of 30 minutes under the preceding conditions in the event of a power line failure. The battery will automatically be fully recharged 16 hours after power is restored.

Patient Immobilizing Strap (G22-147C)

Consists of two straps, one 71 cm long and one 102 cm long. Straps can be joined together to wrap completely around the stretcher to restrain a patient.

The Ellis Nominal Single Dose Slide Rule (G22-224)

The Slide Rule facilitates rapid calculation of the dose per fraction using the NSD concept derived by DR. F. ELLIS, ref. BJR, Vol. 44, pg. 101-105. The Slide Rule is furnished with a detailed instruction manual containing tables and graphs which are required for its full utilization.

J. STANDARD UNIT LISTING

Cat.No.	Description
G2000A	ELDORADO 78, Vertical Stand Cobalt-60 Unit (includes a Spare Printed Circuit Board Kit G19-155C).

K. INSTALLATION OF COBALT-60 TELETHERAPY UNITS

The Cobalt-60 unit shall be installed in the uppointed location by Atomic Energy of Canada Limited personnel, or by personnel appointed by an accredited agent or representative of Atomic Energy of Canada Limited.

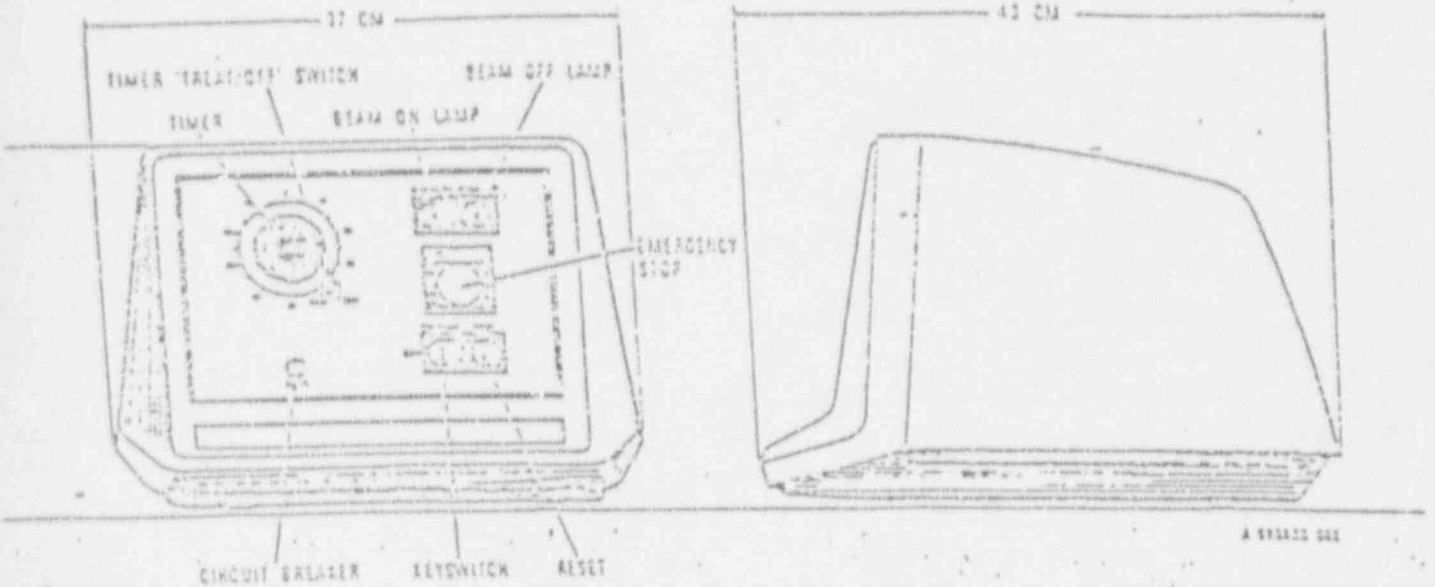
Installation of the unit shall include:

1) Erection of the unit in a suitable location provided by the purchaser, and connection of the unit and control station to a suitable source of electric power provided by the purchaser.

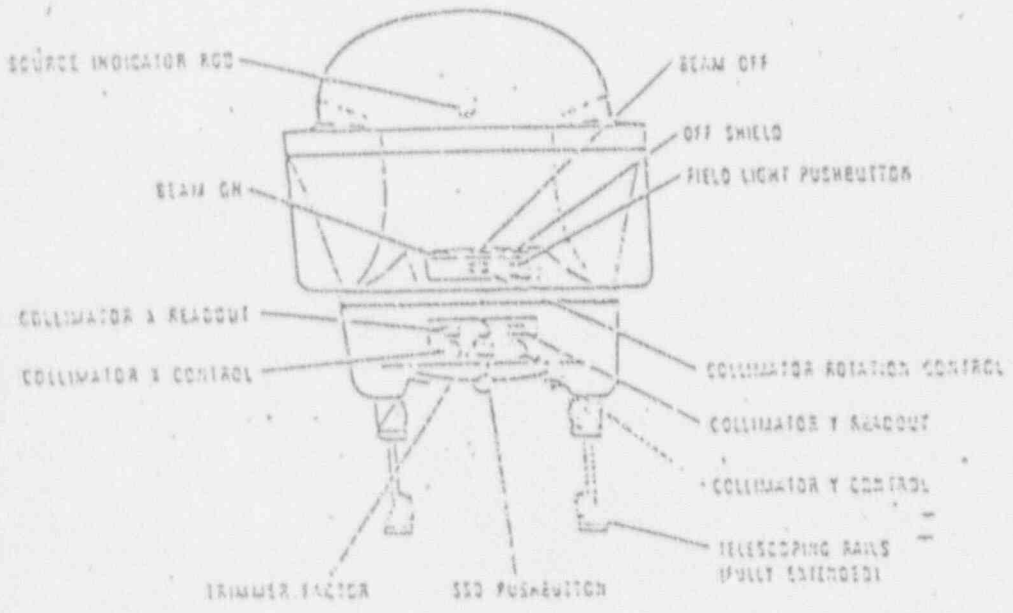
2) A complete operational test of the unit and control equipment.

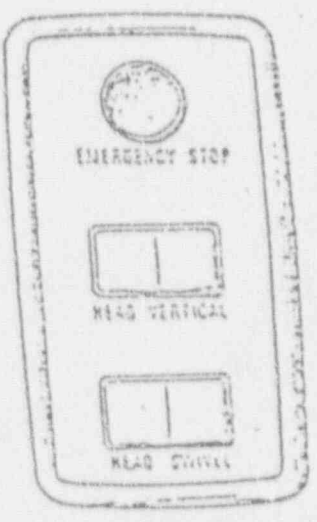
3) Familiarization of clinic personnel with all aspects of the function and control of the unit.

4) In those instances where the source is shipped separately from the sourcehead, the installation shall include the loading of the source into the sourcehead of the unit from an approved AECL source transfer container.



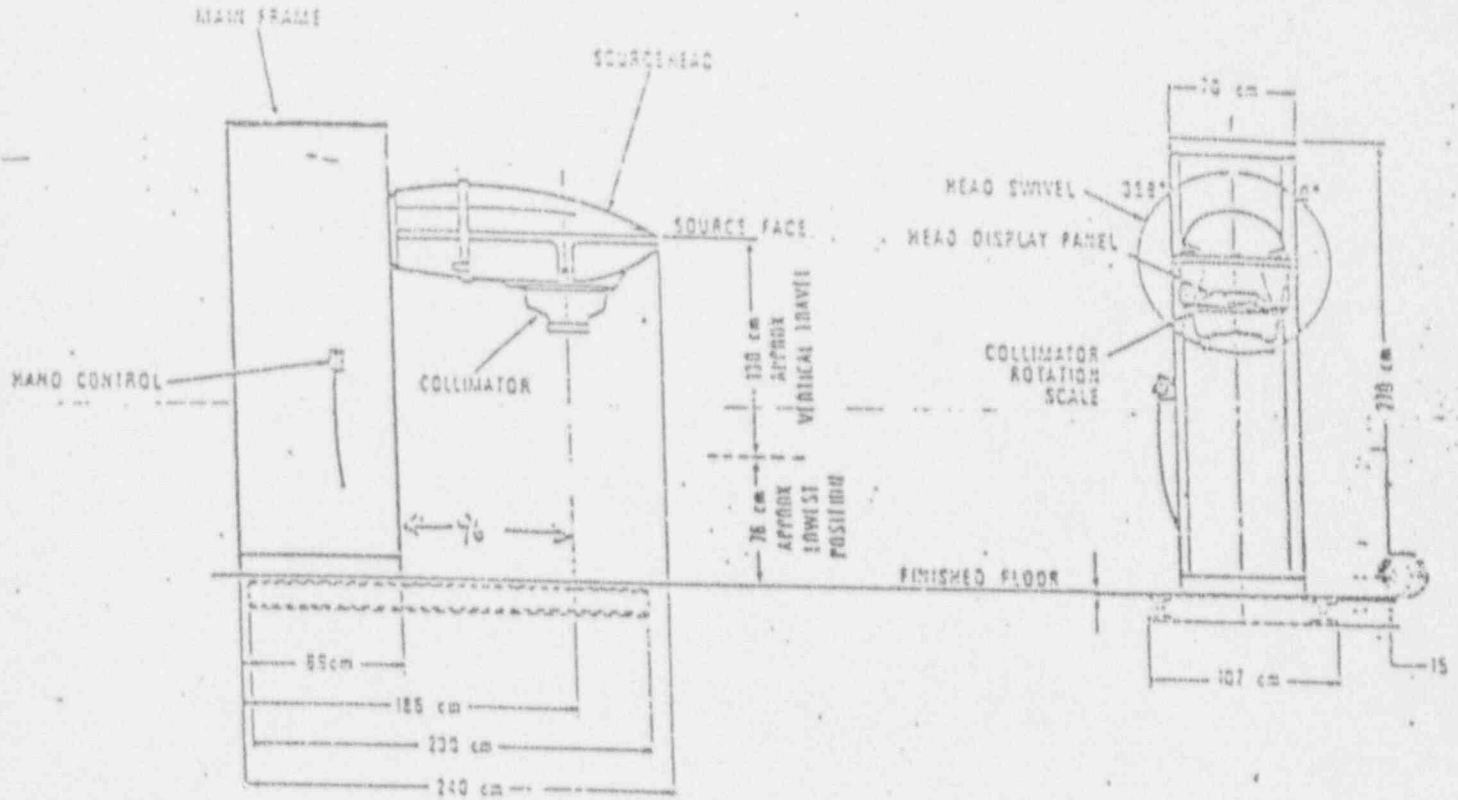
CONTROL CONSOLE PANEL

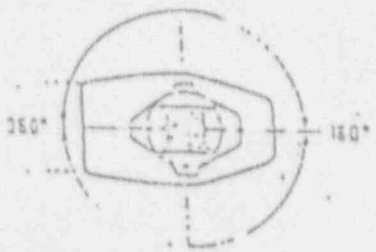




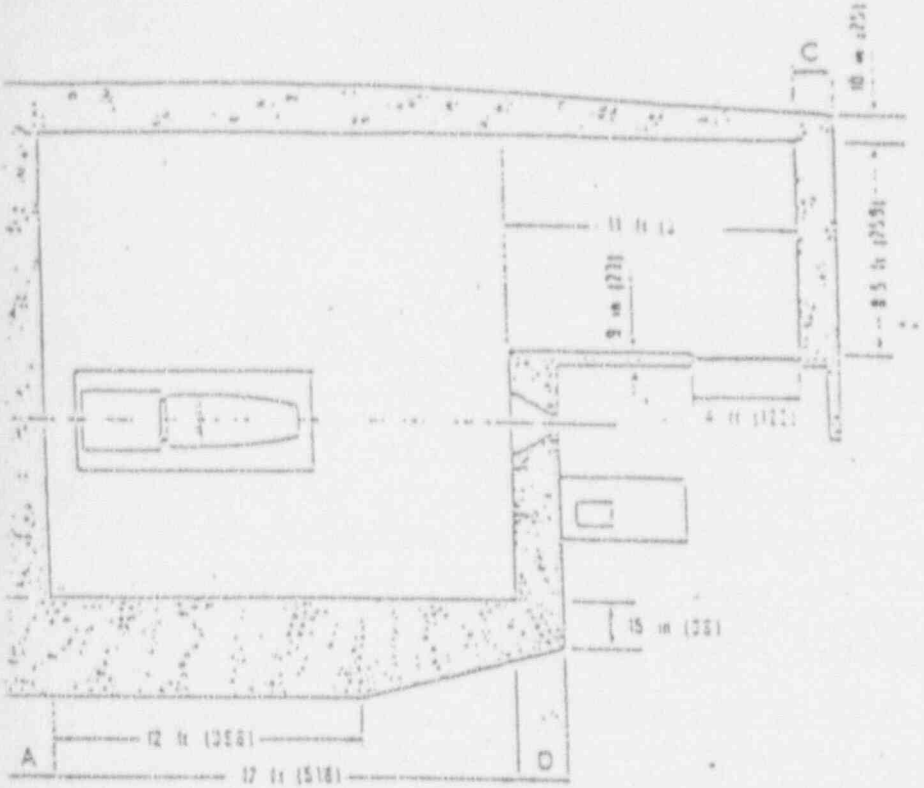
HEAD & COLLIMATOR CONTROL PANELS

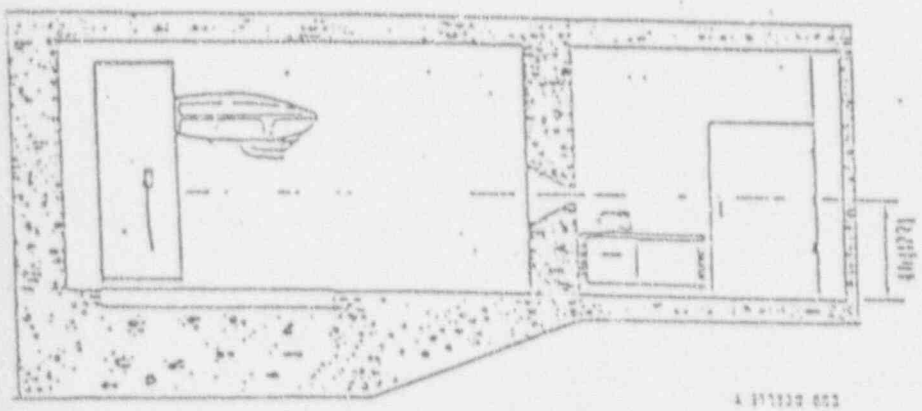
SET-UP CONTROL





GENERAL DIMENSIONS





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NOTE:-

1. Beam Limitations for Layouts Shown:- Sourcehead Swivel - 90° between floor and thickest wall (Shield E).

2. Shielding Design Criteria:-

   a) The Table below details wall thickness required to reduce average dose rates to 5 mR/hr. and to 0.5 mR/hr for 200 Rmm, for various source strengths.

   b) Concrete Density - 147 lb/cu. ft. (2.35 g/cc). If concrete density is less than 147 lb/cu. ft. (2.35 g/cc), increase wall thickness by the density factor, eg. if 16 in (41 cm) of concrete is shown and available concrete density is 138 lb/cu. ft. (2.21 g/cc), wall thickness required is:- 16(41) x 147(2.35)/138(2.21) = 17(43).

   c) Maximum dose rates will, in general, be higher than 5 mR/hr, but will only be encountered under extreme conditions of unit and patient set-up.

   d) Window Dimensions - 8 in. x 8 in. x 6 in. thick (20 cm x 20 cm x 15 cm).

   e) Window Density - 6.2 g/cc (other densities and thicknesses may be required if licensing regulations and/or source sizes dictate).

   f) Window Location - On the centre line of head swivel. (Approximately 4 ft. above the floor.)

   g) Lead Lined Door - 5 mm lead.

3. Shielding Design Approval - Final room design must be approved by qualified physicist before installation of the unit. Where licensing regulations require, room design must also be approved by the local health authority.

	CONCRETE THICKNESS TO REDUCE AVERAGE DOSE RATES TO 5 mR/hr									CONCRETE THICKNESS TO REDUCE AVERAGE DOSE RATES TO 0.5 mR/hr			
	[illegible]		[illegible]		[illegible]		[illegible]		MAXIMUM DOSE RATE [illegible]		[illegible]		MAXIMUM DOSE RATE [illegible]
SHIELD	in	cm	in	cm	in	cm	in	cm		SHIELD	in	cm	
A	14	35	15	38	16	41	17	43	10	A	12	46	1
B	15	41	17	43	18	46	19	48	10	B	17	43	1
C	11	28	12	31	13	33	14	36	10	C	20	51	1
D	14	36	15	38	16	41	17	43	10	D	22	56	1
E	35	89	36	91	37	94	39	100	10	E	47	120	1
F	12	31	13	33	14	36	15	38	11	F	13	33	2.5
G	42	106	43	109	44	112	46	116	10	G	54	137	1

* For an assumed YEAR OR time of 20 hours per week, based on NCRP Report No. 34

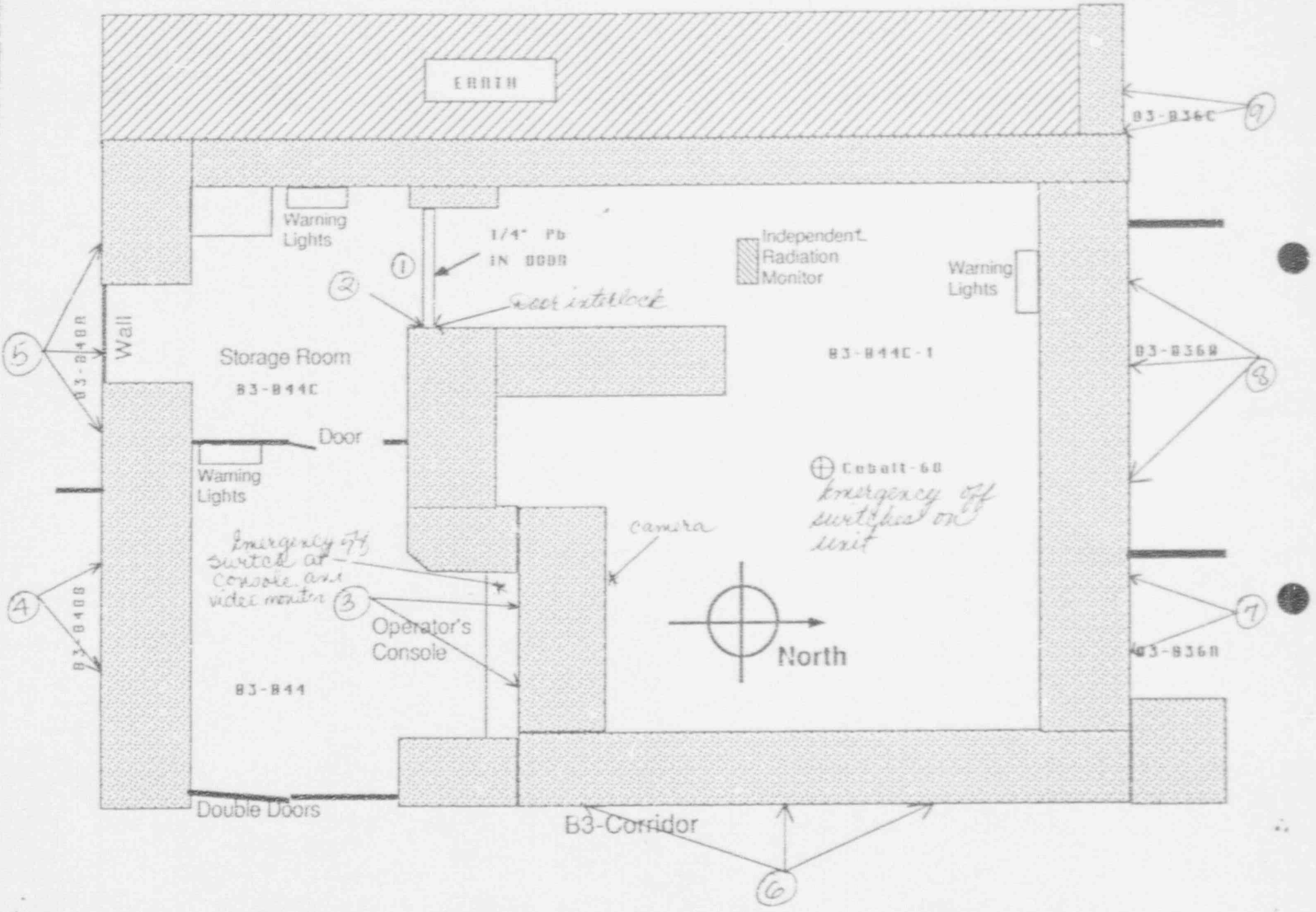
TYPICAL ROOM LAYOUT

Results of surveys conducted 11/17/86 and 11/28/86 to determine maximum exposure levels in each area adjoining room B3-B44C-1 in NIH Building 10 which contains an Eldorado 78 Co-60 irradiator (NRC License No. 19-00296-20). Measurements made with BICRON ion chamber. Beam will be directed toward floor or west wall only.

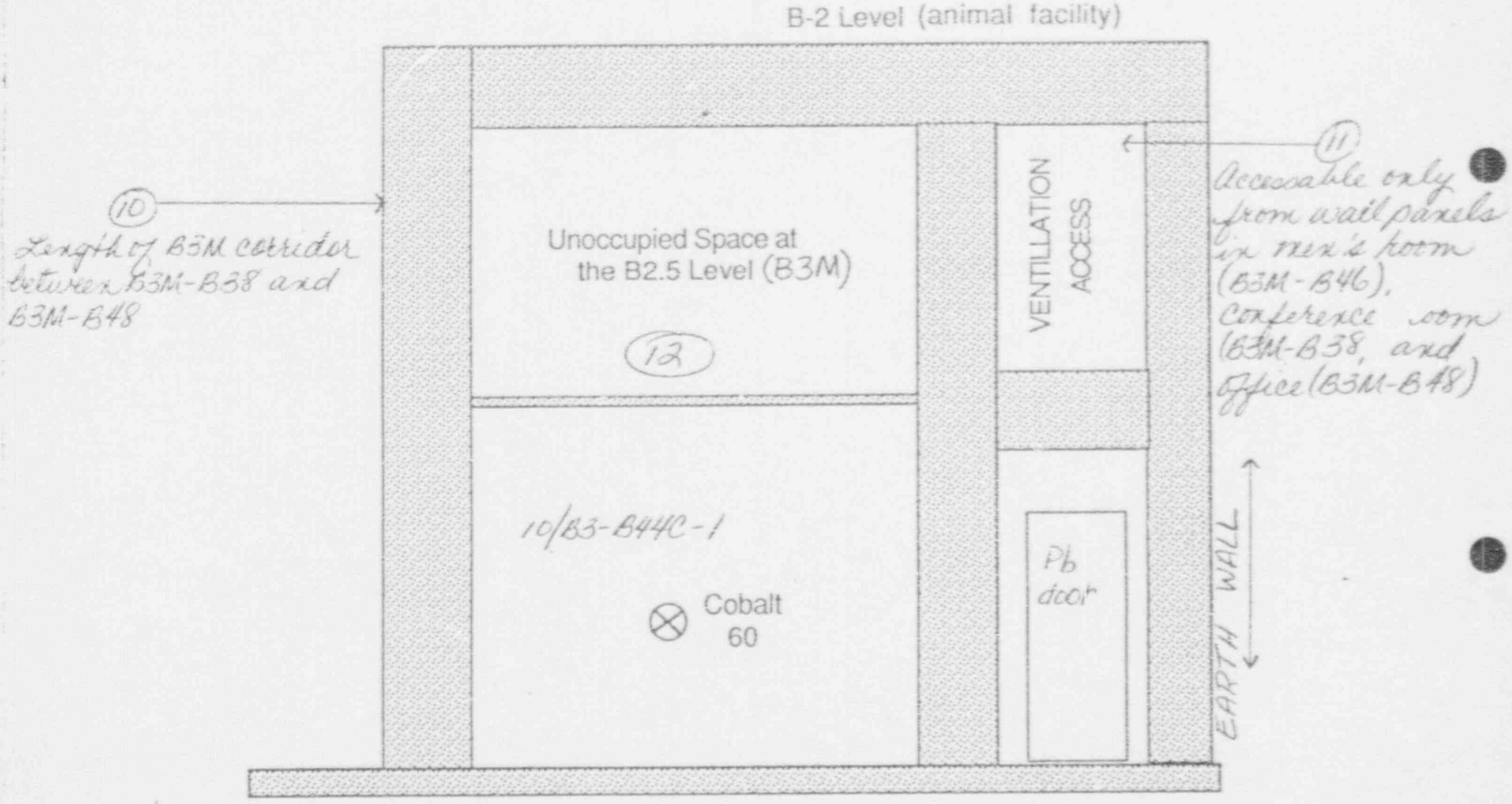
LOCATION of MEASUREMENTS (See attached drawings)	BEAM DIRECTED TOWARD WEST WALL	BEAM DIRECTED TOWARD FLOOR
(1) inside doorway to B3-B44C-1; door open, beam on (irradiator will never be operated in this condition)	6.5 mR/hour	0.7 mR/hour
(2) space between door to B3-B44C-1 and wall; door closed, beam on	0.4 mR/hour	< 0.1 mR/hour
(3) wall at operator's console	< 0.1 mR/hour	< 0.1 mR/hour
(4) adjoining wall B3-B48B (Office)		
(5) adjoining wall B3-B48A (Office)		
(6) adjoining B3-Corridor wall		
(7) adjoining wall B3-B36A (lab)		
(8) adjoining wall B3-B36B (dark room)		
(9) adjoining wall B3-B36C (lab)		
(10) length of B3M corridor between B3M-B38 and B3M-B48; irradiation room is below an unoccupied space on B3M level which is behind B3M corridor wall between B3M-B44 (ladies room) and B3M-B38 (conference room)		
(11) wall panels in B3M-B46 (men's room), B3M-B38 (conference room) and B3M-B48 (office) which are only access points to ventilation area		
(12) No measurements made here; not accessable		

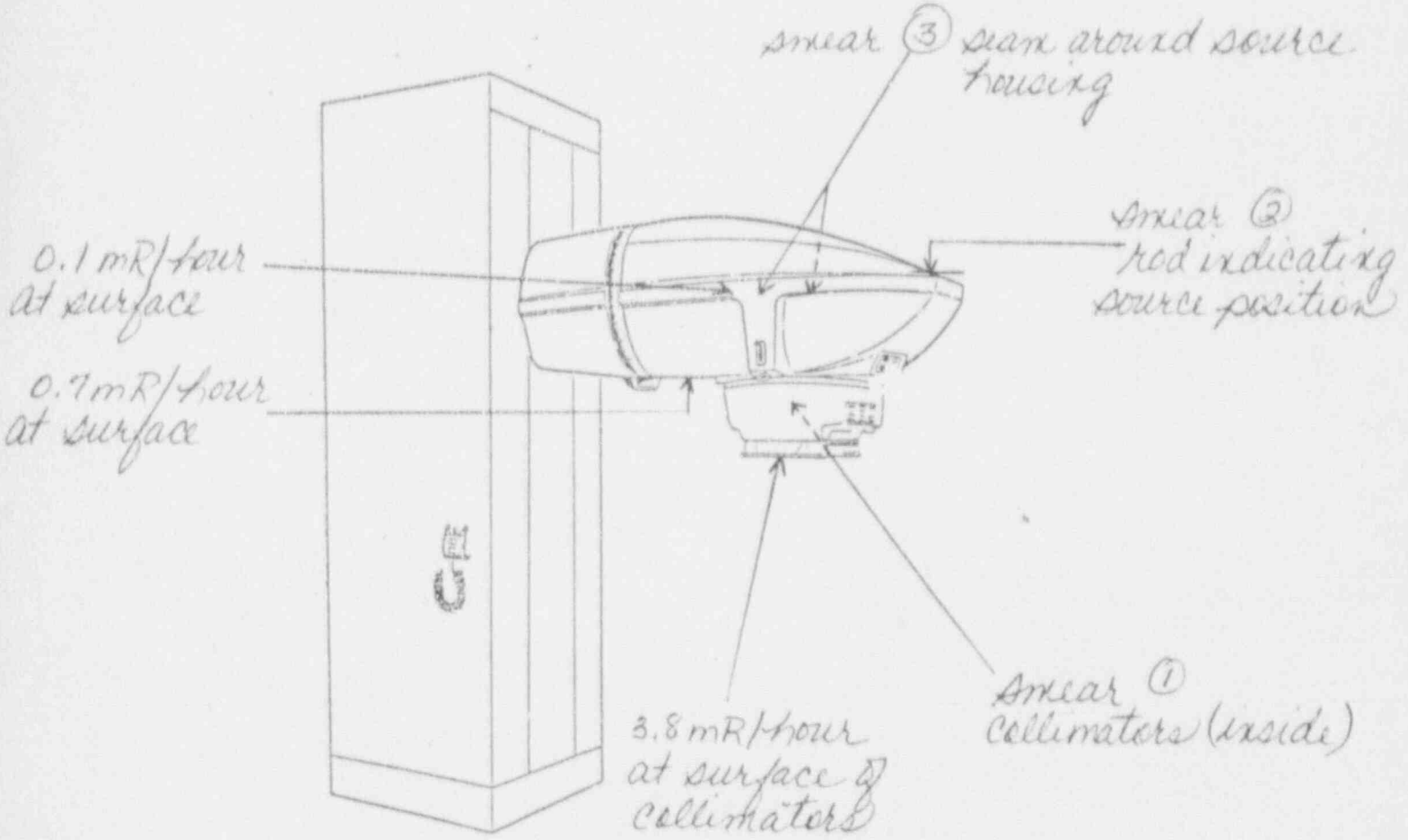
ATTACHMENT 313-9

Location of Exposure Rate Measurements Made 11/17/86 and 11/28/86 L Jenkins



Location of Exposure Rate Measurements Made 11/28/86 L Jenkins





Leak test and Exposure Rate Measurements 11/17/86
AECL Eldorado 78 Co-60 irradiator
Building 10 Room B3-B44C-1

All smears showed <0.05 μCi* removable contamination. Exposure rate measurements made with BICRON ion chamber. All safety (door) interlocks, emergency OFF switches, warning lights and radiation monitor were checked and found to be operating properly.

115574

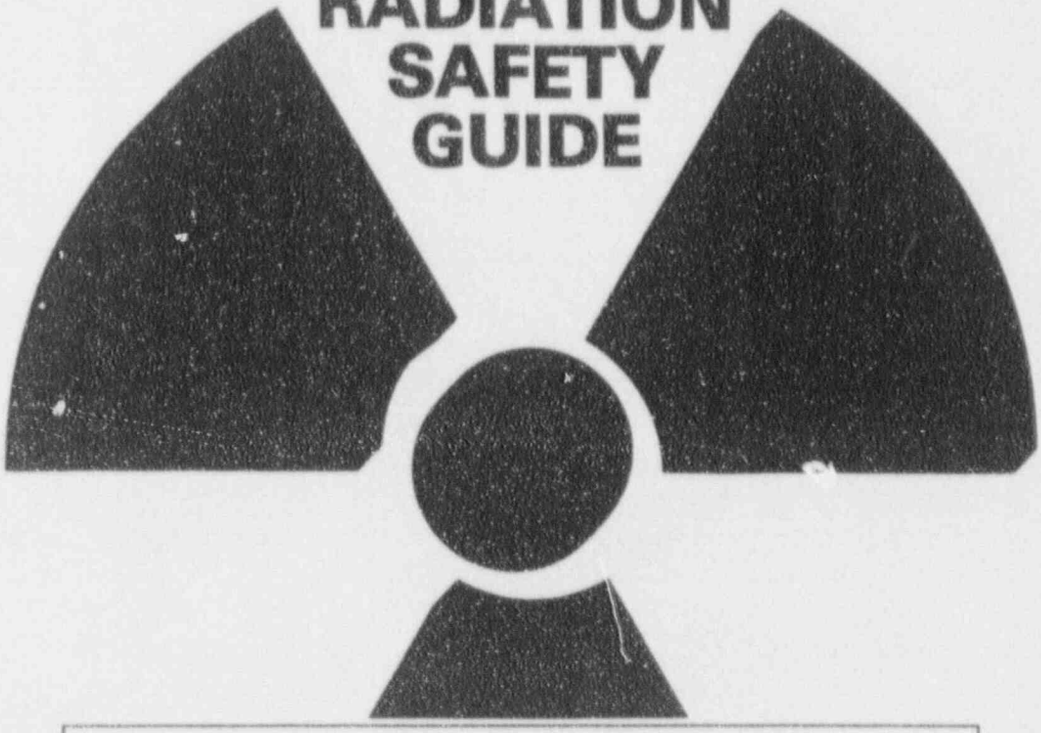
*Limit for removable contamination was ≤ 0.05 μCi at time of this survey. Current limit for removable contamination is ≤ 0.005 μCi. L Jenkins 9/24/91

L. Jenkins

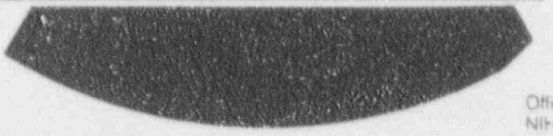
Attachment 313-10

EXCERPTS FROM:

THE NATIONAL INSTITUTES OF HEALTH RADIATION SAFETY GUIDE



INCLUDING:
REVISED 10 CFR PARTS 19 & 20 (1-1-87 Ed.)
REVISED NRC REGULATORY GUIDE 8.13 (12-87 Ed.)
REVISED NRC FORM 3 (5-88)



U.S. DEPARTMENT OF
HEALTH, EDUCATION,
AND WELFARE
Public Health Service
National Institutes
of Health

Office of Administrative Services
NIH Safety Guide Series
Prepared by the
Radiation Safety Branch
Division of Research Services

RADIATION SAFETY BRANCH
DIVISION OF SAFETY
JULY 1988

Foreword

The 1979 edition of the NIH Radiation Safety Guide brings up to date the recommendations and requirements governing the use of radiation sources by the NIH Intramural Program.

NIH is using radionuclides in increasing quantities, under a specific license of broad scope issued by the U.S. Nuclear Regulatory Commission. Possession of this license has greatly reduced the detailed problems of radionuclide procurement, but carries strict responsibilities governing use and ultimate disposal. NIH considers the NRC regulations as minimum requirements, and has broadened local controls to include radiation sources not under NRC surveillance.

Recommendations in the 1979 Guide have developed from years of experience in adapting general principles of radiation safety to the NIH environment. The procedures outlined in the Guide are designed to permit the maximum beneficial use of radiation sources with the minimum exposure to patients and personnel. Failure to follow the recommended procedures could result in a serious radiation overexposure, and a suspension or revocation of our license. All personnel using radiation sources are expected to become familiar with the NIH radiation safety requirements and to conduct their operations in accordance with them.

Donald S. Fredrickson, M.D.
Director
National Institutes of Health

Introduction

The National Institutes of Health is authorized to procure and use radioactive materials on the Bethesda reservation under a "specific license of broad scope" issued by the Division of Materials Licensing of the Nuclear Regulatory Commission. This license is contingent upon the existence of a Radiation Committee and a Radiation Safety organization which, among other requirements must:

1. Assure that any investigator using radioactive materials is qualified by training and experience, has the facilities to handle the materials safely, and proposes a use which is safe to all concerned.

2. Assure observance of all safety standards established by the Nuclear Regulatory Commission, National Council on Radiation Protection and Measurements, and other regulatory or standards setting agencies.

3. Keep records of the receipt, storage, use, transfer, and ultimate disposal of all radionuclides used at NIH.

4. Keep records of the monitoring of personnel and areas involved in the use of radionuclides and other sources of ionizing radiation.

NIH is subject to periodic inspections by the Division of Regulatory Operations of the Nuclear Regulatory Commission to insure that all requirements of the license are being met. These inspections are very thorough, including monitoring checks of laboratory areas, inspection of procurement and disposition records, records of the qualifications of individual users, and records of administrations to patients. Violations of license requirements can result in a loss of the license.

All sources of ionizing radiation are not covered by the Nuclear Regulatory Commission license. These sources are, however, controlled by regulations issued by the Director, NIH, upon recommendation of the Radiation Committee. Non-license sources include x-ray machines, high voltage accelerators, electron microscopes, and radioactive materials from sources other than reactor by-products.

This Guide describes rules and procedures required of NIH under the terms of NRC licensure, and for the use of non-licensed ionizing radiation sources as set forth by NIH regulations.

In total, the 1979 revision of the NIH Radiation Safety Guide represents several decades of intramural experience. Additionally, it reflects authoritative standards, guidelines, recommendations and research data concerning physical aspects and bioeffects of ionizing radiation obtained from the scientific literature.

Previous editions of this Guide included a reasonably comprehensive bibliography of the most important of these sources; the literature is now so extensive, however, that it is not feasible to include even a highly selective bibliography. Therefore, readers who desire documentation for any particular policy, procedure or quantitative data contained in these pages are invited to communicate directly with the NIH Radiation Safety Office.

Contents

National Institutes of Health Radiation Protection Guide

Ionizing radiation is among the most versatile and useful tools of modern medicine and biomedical research. Like many other instrumentalities of medicine and research, ionizing radiation is potentially hazardous unless used with strict adherence to safety rules and procedures.

The risk of unguarded exposure to ionizing radiation includes the possibility of damage to future generations. Thus the safety rules which govern all uses of ionizing radiation are as concerned with preventing genetic damage as with protecting the health of the exposed individual. When followed faithfully, these rules limit exposures of radiation workers to levels far below those which might cause any adverse somatic or genetic effects.

The rules and procedures set forth in this Guide have one single, straightforward purpose—to protect NIH patients and employees against unnecessary and potentially harmful radiation exposure.

Four stages of group and individual responsibility are involved in the radiation safety program. All are equally important:

Radiation Committee: this is a high-level group of physicians and scientists appointed by the NIH Director to establish policies and regulations governing the use of ionizing radiation in NIH intramural programs.

Radiation Safety Office: an operating group of trained health physicists and technicians which is responsible for NIH-wide compliance with these policies and regulations; it also provides a variety of technical services necessary to achieving such compliance.

Individual Users: physicians, scientists, other professionals, as well as technical and other workers engaged in patient care, clinical and laboratory research, and research support activities which involve actual use and handling of materials and devices producing ionizing radiation. These personnel usually work under the immediate supervision of Authorized Users.

Authorized Users: physicians and laboratory scientists whose training and experience are such that they have been authorized by the Radiation Committee to use ionizing radiation in their clinical care, clinical research, and laboratory research activities.

In the following pages detailed descriptions are given of the responsibilities of each of these four categories. Information is also provided on policies, rules and procedures for various particular aspects of ionizing radiation source procurement and usage. Careful observance of responsibilities, rules and procedures set forth in this Guide will insure adequate protection against unnecessary exposure to ionizing radiation.

Radiation Committee Responsibility

The Radiation Committee is composed of ten members appointed by the Director, NIH. The membership consists of one group of five physicians who are nominated by the Medical Board and, in conformity with NRC recommendations, is made up of one hematologist, one radiologist, one pathologist, one internist, and one physician with broad background in the use of radionuclides. A second group of four scientists is nominated by the Scientific Directors. At least one of these scientists is to be a radiation physicist with training and experience in health protection. The Chairman of the Radiation Committee, the Radiation Safety Officer, and a representative of the Office of the Director are appointed by the Director, NIH. The Committee shall have jurisdiction over radiation sources and activities in areas under NIH control, including intramural program off-site use.

Functions

(a) Recommend policies regarding patient and plant radiation safety to the Director, NIH.

(b) Provide technical advice to the Radiation Safety Officer on matters regarding radiation safety.

(c) Receive, review, and act on all applications for the use of radiation sources in any areas used by NIH personnel. These sources include radionuclides to be used in human subjects.

(d) Receive and review periodic reports from the Radiation Safety Officer on monitoring, contamination, and personnel exposure.

(e) Periodically review the overall use of radiation sources at NIH from the standpoint of operational hazards.

(f) Review all instances of alleged infraction of use and safety rules with the Radiation Safety Officer and the responsible Clinical and Scientific Directors before submitting reports or recommendations to the Director, NIH.

Radiation Safety Office Responsibility

The Radiation Safety Office, under the direction of the NIH Radiation Safety Officer, is responsible for:

1. General surveillance of all health physics activities, including both personnel and environmental monitoring.

2. Furnishing consulting services to personnel at all levels of responsibility on all aspects of radiation protection.

3. Receiving, delivering, and shipping all radioactive materials coming to or leaving the NIH reservation.

4. Assaying and performing radionuclidic purity checks on all radioactive materials to be used in humans for therapeutic purposes.

5. Monitoring all accelerators and other machines capable of producing penetrating radiations. Calibrating the output of these machines as requested.

6. Distribution and processing of personnel monitoring equipment, including the keeping of records of internal and external personnel exposure, and notifying individuals and their supervisors of exposures approaching the maximum permissible amounts and recommending appropriate remedial action.

7. Instructing personnel in proper procedures for the use of radioactive materials.

8. Supervision and coordination of the waste disposal program, including the keeping of waste storage and disposal records.

9. Operation of and the allocation of space in the Radionuclide Laboratory, Building 21. This laboratory is equipped for the handling of high levels of activity. Space is available in this laboratory to all NIH workers on an allocation basis. Non-tracer level radionuclide work will be done in this building unless the Radiation Committee grants approval to do the work elsewhere.

10. Storage of all radioactive materials not in current use.

11. Performing leak test on all sealed sources.

12. Maintaining a periodic inventory of all radioactive materials on the NIH reservation.

13. Supervising decontamination in cases of contaminating accidents.

14. Maintaining a continuous program of environmental radiation hazard evaluation and hazard elimination.

Individual User Responsibility

Each individual at NIH who has any contact with radioactive materials is responsible for:

1. Keeping his exposure to radiation as low as possible, and specifically below the maximum permissible exposure as listed in the following table:

REMS PER CALENDAR QUARTER	
Whole body; head and trunk; active blood-forming organs; lens of eyes; or gonads	1.25
Hands and forearms; feet and ankles	18.75
Skin of whole body	7.5

Also see additional guidelines for maximum permissible doses, e.g., for fertile females and the fetus on pg. 45-51.

Laboratory air and water concentrations shall be maintained below the levels listed in the Code of Federal Regulations, Title 10, Part 20 (10 CFR 20) "Standards for Protection Against Radiation." (See Appendix)

2. Wearing the prescribed monitoring equipment such as film badges and pocket dosimeters in radiation areas. Personnel who work only with pure alpha emitters or only with pure beta emitters having a maximum energy of less than 0.2 MeV will not be required to wear film badges.

3. Surveying his hands, shoes, and body for radioactivity, and removing all loose contamination before leaving the laboratory to smoke, eat, etc.

4. Utilizing all appropriate protective measures such as:

(a) Wearing protective clothing whenever contamination is possible, and not wearing such clothing outside of the laboratory area.

(b) Wearing gloves and respiratory protection when necessary.

(c) Using protective barriers and other shields whenever possible.

(d) Using mechanical devices whenever their aid will assist in reducing exposure.

(e) Using pipette filling devices. *Never pipette radioactive solutions by mouth.*

(f) Performing radioactive work within confines of an approved hood or glove box unless serious consideration has indicated the safety of working in the open.

5. Involving smoking or eating in radionuclide laboratories. It is recommended that eating be done in the cafeterias whenever possible. Smoking or eating may be permitted in an office area of a laboratory that has been demonstrated to be free of contamination. Refrigerators shall not be used jointly for foods and radioactive materials.

6. Maintaining good personal hygiene.

(a) Keep fingernails short and clean.

(b) Do not work with radioactive materials if there is a break in skin below the wrist.

(c) Wash hands and arms thoroughly before handling any object which goes to the mouth, nose, or eyes.

7. Checking the immediate areas, e.g., hoods, benches, etc., in which radioactive materials are being used, at least once daily for contamination. A log record should be maintained of these surveys including results which are entirely negative. Any contamination observed should be clearly marked and the Radiation Safety Office notified.

8. Keeping the laboratory neat and clean. The work area should be free from equipment and materials not required for the immediate procedure. Keep or transport materials in such a manner as to prevent breakage or spillage (double container), and to insure adequate shielding. Wherever practical, keep work surfaces covered with absorbent material, preferably in a stainless steel tray or pan, to limit and collect spillage in case of accident.

9. Labeling and isolating radioactive waste and equipment, such as glassware, used in laboratories for radioactive materials. Once used for radioactive substances, equipment should not be used for other work, and *shall not be sent from the area to central cleaning facilities, repair shops, or to surplus, until demonstrated to be free of contamination.*

10. Requesting Radiation Safety office supervision of any emergency repair of contaminated equipment in the laboratory by shop personnel or by commercial service contractors. At no time shall servicing personnel be permitted to work on equipment in radiation areas without the presence of a member of the laboratory staff to provide specific information.

11. Reporting accidental inhalation, ingestion or injury involving radioactive materials to his supervisor and the Radiation Safety Office, and carrying out their recommended corrective measures. The individual shall cooperate in any and all attempts to evaluate his exposure.

12. Carrying out decontamination procedures when necessary, and for taking the necessary steps to prevent the spread of contamination to other areas.

13. Complying with requests from the Radiation Safety Office for body burden measurements in the whole body counter and the submission of urine samples for radioassay. Requests for these tests will be made in the case of workers using significant quantities of both γ and β emitters.

Authorized User Responsibility

Authorized users are responsible for insuring that the preceding individual responsibilities are discharged by those under their control, and are further responsible for:

1. Adequate planning. Before an experiment is performed, the supervisor should determine the types and amount of radiation or radioactive material to be used. This will generally give a good indication of the protection required. The procedure must be well outlined. In many cases, before the procedure is actually performed with radiation, it should be rehearsed so as to preclude slip-ups or unexpected circumstances. In any situation where there is appreciable radiation hazard, the Radiation Safety Office shall be consulted before proceeding.

2. Instructing those employees for whom they are responsible in the use of safe techniques and in the application of approved radiation safety practices and insuring attendance in required radiation safety courses.

3. Furnishing the Radiation Safety office with information concerning individuals and activities in their areas—particularly, pertinent changes in their personnel rosters.

4. Contacting the Radiation Safety Office whenever major changes in operational procedures, new techniques, alterations in physical plant (e.g., the removal of radiochemical fume hood), or when new operations which might lead to personnel exposure are anticipated.

5. Complying with the regulations governing the use of radioactive materials, as established by the NRC and the NIH Radiation Committee, for:

(a) Correct procedure for the procurement of radioactive materials by purchase or transfer. (See procedure for Procurement of Radiation Sources.)

(b) Posting areas where radionuclides are kept or used, or where radiation fields may exist.

(c) Seeing that each sign carries the name of the personnel currently responsible for the associated area.

(d) Recording the receipt, transfer, and disposal of radioactive materials in his area. This includes sealed sources such as ion sources in gas chromatographs and static eliminators. The authorized user must be prepared to submit semiannually the required inventory data upon request.

(e) Assuring that all radioactive waste materials are consigned to the Radiation Safety Office for disposal.

(f) Taking steps to prevent the transfer of radioactive materials to unauthorized individuals. This includes the proper disposition of radioactive materials possessed by terminating workers.

6. Keeping stocks of stored radioactive materials to a minimum within laboratory areas. Authorized users should employ the storage facilities of the Radionuclide Laboratory, Building 21, for shipments not needed in current research.

7. Complying with proper procedure for termination of employment or termination of any experiment using radioactive materials. The authorized user is reminded that, under the terms and conditions of the NRC-NIH license, he must return to the Radiation Safety Office all radioactive materials, including waste, assigned to him under the license. Particular care should also be exercised to see that specialized equipment such as personnel monitoring devices (e.g., film badges), survey instruments, and shielding materials are returned to the Radiation Safety Office. A final termination survey should also be requested by telephone.

Policies and Procedures for Radionuclide Areas

In addition to the Code of Federal Regulations, Title 10, Parts 19 and 20, as appended to the Guide, the following policies and procedures will apply to the NIH license:

1. Proper Marking of Laboratories, Areas, and Equipment

(a) A "CAUTION RADIOACTIVE MATERIALS" sign must be conspicuously posted on the doors to laboratory areas where radioactive materials are being used or stored. The name and home phone number of the individual responsible for the posted area shall be shown in the designated place on the sign in order to facilitate contact in case of emergency. The supervisor shall be responsible for seeing that the posted information is current. The signs must not be removed from any room except by Radiation Safety personnel following an inspection survey.

(b) Storage areas shall be conspicuously marked with a "CAUTION RADIOACTIVE MATERIALS" sign. In addition, containers in which materials are transported or stored shall bear a durable, clearly visible label bearing the radiation caution symbol and the words "CAUTION RADIOACTIVE MATERIALS." This label shall also state the quantities and kinds of radioactive materials in the containers and the date of measurement of the quantity.

(c) Radiation areas in the laboratory, i.e., areas where radiation levels might expose individuals to 5 millirem in any one hour; or in any five consecutive days, a dose in excess of 100 mrem, shall be posted with the sign "CAUTION RADIATION AREA."

(d) All equipment contaminated with radioactive material shall be marked with signs, decals, or other conspicuous means. Labeling shall not be required for laboratory containers such as beakers, flasks, and test tubes, used transiently in laboratory procedures during the presence of the user.

(e) All signs referred to in this part are available from the Radiation Safety Office, Building 21.

2. Shielding of Sources

(a) Radioactive sources or stock solutions in the laboratory shall be shielded in such a manner that the radiation levels in any occupied area will not expose individuals in the area to more than 100 mrem in any five consecutive days.

(b) Various shielding materials are available on loan from the Radiation Safety Office.

3. Aerosols, Dusts, and Gaseous Products

(a) Procedures involving aerosols, dust or gaseous products, or procedures which might produce airborne contamination shall be conducted in a hood, dry box, or other suitable closed system.

(b) All releases from such systems shall not exceed the maximum permissible concentration in air for the nuclide in question. See Appendix B, Table II of 10 CFR 20 for appropriate values. However, where practical, traps should be incorporated in the experimental set-up to insure that environmental releases are as low as possible.

(c) Radioactive gases or materials with radioactive gaseous daughters must be stored in gas-tight containers and must be kept in areas having approved ventilation.

(d) Hoods to be used for radionuclide work should be tested by the Environmental Services Branch, DRS, to insure that they meet the minimum requirements for air velocity at the face of the hood.

4. Sealed Radioactive Sources

(a) All sealed radioactive sources must be shipped to: Radiation Safety Officer, National Institutes of Health, Building 21, Radionuclide Laboratory, Bethesda, Maryland 20014. Each source must be registered with this office.

(d) For those sources which may change location frequently, the Radiation Safety Office in cooperation with individual users shall establish strict accountability procedures.

(c) Sealed sources shall be leak tested by Radiation Safety personnel prior to initial use and at least every six months thereafter.

5. Radioactive Materials in Gas Chromatography Equipment

All gas chromatography units in which radioactive materials are to be used are regulated as follows:

(a) As is true with other radioactive shipments, radioactive foils to be used in gas chromatography cells must be shipped to: Radiation Safety Officer, National Institutes of Health, Building 21, Radionuclide Laboratory, Bethesda, Maryland 20014. Each foil must be registered by number with this office.

(b) In addition, each cell containing a radioactive foil must have a label showing:

The radiation caution symbol with the words "CAUTION RADIOACTIVE MATERIAL"; and

The identity and activity of the radioactive material.

The radioactive foil shall not be removed from its identifying cell except for cleaning and shall not be transferred to other cells.

(c) The following notice shall appear in a conspicuous location on the outside of each gas chromatography unit: "This equipment contains a radioactive source registered with the NIH Radiation Safety Office as required by license from the Nuclear Regulatory Commission. Notify the Radiation Safety Office before removing the source from this room or area, or upon any change in custodial responsibility." These notification tags are available from the Radiation Safety Office, Building 21.

(d) Individuals using radioactive components in gas chromatography equipment must vent the cell-exhaust through plastic tubing into a hood, room exhaust, or Radiation Safety approved trap, to avoid contamination of work areas from the release of radioactive tagged samples introduced into the system or from the accidental overheating of radioactive foils in the cells.

(e) The Radiation Safety Office will perform periodic leak tests, store radioactive foils when not in use, and maintain the necessary records on such tests and storage.

6. Work Surfaces

All work areas (bench tops, hood floors, etc.) as well as storage areas and areas adjacent to permanent set-ups and sinks should be covered at all times with stainless steel or plastic trays, uncracked glass plates, or other impervious materials. For some purposes a plastic-backed absorbent paper (e.g., "Kimpak", available from the Central Storeroom) will be satisfactory. However, if such paper is used, it should be discarded frequently to prevent radioactive materials from dusting off the surface.

7. Periodic Surveys of Radiation Areas

The immediate areas (e.g., hoods, bench tops) in which radioactive materials are being used should be checked for contamination at least once daily by the radiation workers in that laboratory. In addition, these areas should be inspected each and every time there is reason to suspect a contamination incident. *Records shall be kept on both positive and negative survey results in the authorized user's laboratory logs.*

8. Laboratory Monitors

Each laboratory or area (other than those where ^{3}H is used exclusively or where only exempt quantities of other radionuclides are handled) shall be equipped with a portable or semiportable monitoring device to be used for personnel and area monitoring. Laboratory monitors of this type are available on loan from the Radiation Safety Office.

9. Removal of Equipment from the Laboratory

Once used for radioactive substances, equipment shall not be used for other work, or sent from the area to central cleaning facilities, repair shops, surplus, or returned to the source of supply, until demonstrated to be free of contamination. Equipment to be removed from the Radionuclide Laboratory, Building 21, must be cleared through the Radiation Safety Office.

10. Repair and Maintenance of Equipment in the Laboratory

Equipment to be repaired by shop and maintenance personnel, or by commercial service contractors, shall be demonstrated to be free of contamination prior to servicing. If it becomes necessary to make emergency repairs on contaminated equipment, the work will be supervised by a member of the Radiation Safety Office staff, who will assure that the necessary safeguards are taken. It is the responsibility of the laboratory personnel to request this supervision from the Radiation Safety Office.

11. House Vacuum Lines

House vacuum lines are vulnerable to contamination. If house vacuum lines are to be used, the withdrawn gas must be demonstrated to the Radiation Safety Office to be free of radioactivity. It is advisable to use a separate vacuum system whenever possible, such as a separate vacuum pump exhausting into a hood.

12. Radioactive Contamination of Areas

In general, no radioactive contamination can be tolerated. Exceptions to this will include certain hood trays, dry boxes, stainless steel trays, Kimpak covered surfaces, or other equipment which is used frequently for active work and which will be clearly marked with the standard radiation caution signs or stickers. Any contamination that is not confined to protected surfaces should be reported immediately to the Radiation Safety Office. The Radiation Safety staff will supervise the decontamination of such areas or equipment.

13. Decontamination of Areas Contaminated with Radioactivity

Preparations for decontamination should be begun promptly. Determine the extent and hazard of contamination. The Radiation Safety Office staff will assist in this evaluation. The individual responsible for the contamination will be expected to do most of the cleanup under the supervision of the Radiation Safety staff. After decontamination, the area or equipment shall be considered contaminated until proved otherwise by the Radiation Safety Office.

14. Decontamination of Personnel Contaminated with Radioactivity

(a) Notify supervisor immediately after contaminating accident.

(b) Wash body area involved thoroughly for 2 or 3 minutes, repeatedly "soaping" and rinsing. Consideration should be given to the chemistry of the contaminant and an attempt made to find a suitable agent for dissolving it. Any cleansing agent may be used, but synthetic detergents are preferred to soaps. Avoid prolonged use of any one decontamination procedure. Irritation of the skin may impede the success of more suitable procedures. Avoid the use of organic solvents. They may make the skin more permeable to radioactive contaminants.

(c) If this procedure is not immediately and completely effective, notify the Radiation Safety Office and proceed at once to the Medical Officer in charge of the Building 10 Health Unit, Occupational Medicine Service. Special decontaminating agents such as "Versene", "Radiacwash", etc. may be used under the direction of the Medical Officer.

15. Prophylactic Thyroid Blocking Agents in Laboratories Using Radioiodine

Individuals utilizing greater than 10mCi radioiodine should consult with and follow the recommendations of the Occupational Medical Service prior to the use of prophylactic thyroid blocking agents. Such individuals are reminded that the use of these blocking agents in no way reduces the need to take all other precautions in the safe handling of radioiodine.

Radioactive Waste

No radioactive wastes shall be disposed of by conventional methods. This means particularly that solid wastes may not be placed in the standard waste containers to be collected by housekeeping personnel, and that liquid wastes may not be discharged into the sewer. Animals must not be incinerated in the general purpose incinerator.

No radioactive waste shall be released from a laboratory area for pickup and disposal prior to autoclaving or otherwise suitable deactivation of infectious agent(s). Radioactive waste disposal procedures in the waste handling area of the Radionuclide Laboratory, Building 21, involve crushing and compacting of dry wastes by compaction devices and pooling of liquids in approved shipping containers for disposal by a licensed contractor. These procedures are not compatible with the proper handling of infectious agents. Similar considerations shall also be given to other highly toxic or hazardous substances. (See Section 3)

1. Waste Containers

To insure that solid and liquid wastes are kept separate, each laboratory having radioactive waste must be equipped with at least one container for solid dry waste and one for liquid waste. Due to the methods of ultimate disposal of waste by the Radiation Safety Office, short half-life (less than 30-days) waste must be kept separate from long half-life waste. Additional waste containers shall be re-

quested for this purpose and marked as to the radionuclides being used.

(a) Solid dry waste containers. These may be obtained from the Radiation Safety Office. They must be kept fitted with a disposable waterproof polyethylene liner.

(b) Liquid waste containers. Plastic carboys, glass jars, or bottles are suitable for storage of liquid wastes. If the liquid waste container is glass or ceramic, then it must be kept in such a manner that if accidentally broken, the contents will be retained in a small area, e.g., having it set in a large pan. These liquid containers must possess securely fitting covers or corks, and must be kept closed. In addition, they shall be conspicuously marked with appropriate radiation signs.

(c) Animal carcasses. Small radioactive animals should be placed in the standard polyethylene bags. Larger animals (dogs, etc.) should be placed in large polyethylene bags which will in turn be placed in a cardboard container (NIH Stock No. 4-0870). Each unit must be conspicuously marked with a "CAUTION RADIOACTIVE MATERIAL" sign and in addition, the radionuclide(s) and amount remaining in the carcass shall be posted on the bag or label. If pickup cannot be arranged within 4 hours of sacrifice of animals, such animal carcasses must be refrigerated or preferably frozen.

(d) Liquid scintillation vials. All liquid scintillation vials must be disposed of as radioactive waste. Prior to removal, all liquid scintillation vials must be tightly capped and returned to the original shipping trays.

2. Waste Pickup

Request for removal of liquid and dry waste may be made by telephone to the Radiation Safety Office. At the time of the telephone request and at the time of pickup, the investigator must be able to estimate, with a fair degree of accuracy, the amount of radioactive waste in each container.

3. Unusual Waste Disposal Problems

Plans for proper disposal of infectious agents or highly toxic or hazardous substances shall be made early in the design stage of the experiment.

Proposed procedures involving unusual waste disposal problems will be considered individually by the Radiation Committee or the Radiation Safety Officer and staff.

Physician's Responsibility and Procedures

In carrying out the responsibilities and duties assigned it by the NRC under the Broad License and by the Director, NIH, the Radiation Committee requires compliance with the following policies and procedures:

1. Experience and Training of Applicants

The Committee is bound by the requirements of NRC for training and experience of physicians in the use of radioactive materials. These requirements are listed in "Nuclear Regulatory Commission Licensing Guide—Medical Programs." Copies of this report are available for reference from both the Radiation Committee office and the Radiation Safety Office.

2. Procedures for Making Application to the Committee

A separate application is required for each project which contemplates the use of radioactive materials in humans. This application must include:

(a) Form NIH-88-23: A self-explanatory form available from the Chairman, Radiation Committee.

(b) Narrative description of project which shall include:

(1) Title of the project.

(2) A statement of the purpose and justification for the use of radionuclides.

(3) Description of the project including methods, characteristics of radioactive materials (half-life, nature and energy of emissions, modes of decay), details of doses (single and total) and the anticipated results. Reference to previous work published by the applicant or others concerning animal experimentation or human use (including doses) should be carefully documented. The Committee requires a clear, concise calculation of the anticipated whole body and critical organ absorbed dose in rads, stating the period of such exposure and radiation hazards, if any. Include uptake and excretion data. The formula used for such calculation should be clear, all terms defined, and the source and estimated reliability of the formula indicated. Assumptions used for estimates should be stated. Assay methods and estimated efficiencies should be given.

(4) Methods of waste disposal, particularly with respect to urine, stools, exhaled air, and calculation of the daily amounts of radioactivity to be disposed of into the sewer or air, if any.

(5) Safety precautions which will be initiated to protect the patient, other patients in the vicinity of the radioactive patient, and the patient-care staff and adjunct personnel.

(6) If the use of the radioactive material is planned for normal human subjects, the application must specify minimum ages of these subjects, the fact that they are volunteers, cognizant of the possible radiation hazards, and the status of such normal subjects with respect to other contacts with radiation, and cumulative exposure. In addition, the Radiation Committee requires a short statement from the investigator regarding the information he would supply to the volunteer pursuant to obtaining his consent.

(c) With the first application from each investigator, a complete description of his training and experience, stating periods, location and supervision in the use of radionuclides (Form NIH-88-2, NIH-88-24).

Upon completion, this application should be forwarded through the Branch Chief, and the Clinical Director of the applicant's Institution to the Chairman of the Radiation Committee. Action of the Committee will be returned through channels to the applicant and copies will be forwarded to the Radiation Safety Officer and to the Chief, Radiopharmaceutical Section. The signed approved original will constitute the investigator's authorization under the Broad NRC License to procure and use the materials. Physicians may obtain information on current approved investigators and specific medical uses at NIH from the Radiation Committee office.

Should questions arise in the Committee regarding details of an application, the investigator will be invited to meet with the Committee and discuss the details of his proposal. Should the Committee finally disapprove the application on the basis of conflict with restrictions of the NRC or Director, NIH, or Committee policies, the application nevertheless will be forwarded to NRC for its review and action upon further recommendation of the investigator and his Clinical Director.

Each authorization will be marked with an expiration date which will usually be the last day of the month, one year after the month of the approval. Authorized investigators should anticipate the expiration of their approvals by at least one month and apply for renewal of the authorization. For this purpose, it is necessary to submit only the Form NIH-176 (without narrative description) and a "Summary of Use of Radioactive Materials," Form NIH-88-25. The investigator should clearly state that this is an application for renewal of the previous authorization without modification, and should include the number of the original authorization and date.

If an investigator has no positive plans for the use of a given authorization during the coming year, he should consider its retirement in order to save on bookkeeping in the Radiation Committee, Radiation Safety and Radiopharmacy offices. Such a retired authorization can usually be reactivated by the Chairman, Radiation Committee, in one day should need for it develop.

An authorization which is being considered for renewal and which reflects frequent patient use may be retained and established as a service to be provided to the clinician and patient by the Department of Nuclear Medicine. Decision to provide this service will reside with the Chief, Department of Nuclear Medicine. This service consideration would also be applied in the situation where several similar authorizations by separate applicants reflect an overall need for patient service from various areas of the Clinical Center.

After receiving the approved Form NIH-88-23, the investigator should comply with the procedures "Procurement of Radiation Sources" listed elsewhere in this Guide.

3. Responsibility

The authorized investigator has primary responsibility for the use of the radioactive material; for the protection of the patient, and for the safe handling of any material removed for study. The Radiation Safety staff is responsible for the protection of the patient-care staff, for instructions needed to insure radiation-safe conditions, and for the handling of contaminated materials, equipment, and waste. *Any delegation of work does not shift responsibility.*

Special instructions regarding patient treatment shall be on Clinical Record SF-508. Radiological safety precautions will be recorded on Form NIH-88-7.

4. Justification

The widely accepted policy for medical uses of radionuclides is that radioactive substances should never be used in humans except when the investigation or treatment justifies the risk involved. It is NIH policy to encourage use of the most sensitive instrumentation and assay procedures available, and

to promote progressively better techniques aimed at reducing radiation doses. All research and diagnostic procedures should be designed with these policies in mind.

The therapeutic uses of radiation in other than malignant disease should be well justified. Applications for therapeutic uses of radiation will be reviewed by the Radiation Committee in accordance with instructions from the Director, NIH, and the Medical Board.

5. Dosage Considerations

As a general guide to the maximum permissible dose for normal volunteers and for patients, the Radiation Committee follows the recommendations of the National Council on Radiation Protection and Measurements Report No. 39, "Basic Radiation Protection Criteria" and Code of Federal Regulations, Title 21, (Food and Drugs) Part 361. Insofar as is practical, the Committee considers that the dose to normal subjects and patients should be limited to 3.0 rems to any tissue within a 13 week period or 5 rems annually, when diagnostic and experimental purposes permit. When it is necessary to exceed this dosage for the purposes of research or diagnosis because instrumentation of the required sensitivity is not available, the applicant will be required to provide justification for doses higher than these values. For all normal volunteers under the age of 18 years, and patients under the age of 18 years, and all pregnant women, this limit is reduced to 10% of the above values.

Larger doses will be considered by the Committee for use in patients with limited life expectancy (two years or less) when the application adequately justifies the procedure and the importance of the contribution which is anticipated by the use of such doses.

When considering the utilization of radioactive materials for human research and diagnosis, the investigator is urged to carefully consider the following factors.

(a) Body retention of the radioactive materials.

(b) Accumulation in critical tissues.

(c) Size of critical organ.

(d) Radiosensitivity of the tissue.

(e) Biological half-life.

(f) Effective half-life.

(g) Type and energy of the radiations.

(h) Accumulation of effects of combined or sequentially administered radioactive materials.

(i) Concomitant use of x-radiation.

6. Calibration and Nuclidic Purity Tests

Prior to administration, all radionuclides are to be calibrated and tested for nuclidic purity by the Radiopharmaceutical Section. Indicated pyrogen and sterility testing is to be arranged by the Radiopharmaceutical Section.

7. Notification of Nursing Staff

In order that the nursing staff may prepare for therapeutic radionuclide administration, the head nurse of the nursing unit which will care for the patients should be notified as far in advance as possible, preferably 24 hours or more. Those connected with the administration of the radionuclide should become familiar with nursing procedures to insure uniformity of precautions.

8. Area Designation

It is not necessary to isolate patients with routine diagnostic doses nor to post their rooms. Patients with therapeutic doses should be confined to their individual rooms, as distant from the nursing station as feasible, and the room posted with a "Radiotherapy Precautions" sign (available from the Radiation Safety staff). The Radiation Safety staff will conduct daily surveys of the patient area following therapeutic doses, removing contaminated materials such as urine, soiled bedding, etc., when necessary, and instituting controls so that the patient-care staff, adjunct personnel, and visitors are not exposed to radiation levels in excess of applicable guides. The physician in charge is responsible for requesting assistance from the Radiation Safety staff in the event of contaminating accidents, and prior to removal of the patient from therapy precautions.

9. Record of Patient Doses

The authorization number and any dose of a radionuclide administered to a patient together with the other required data shall be recorded immediately on the patient's chart using Form PHS-412, "Radioactive Isotope Exposure Record."

10. Radioactive Waste and Disposal

Radioactive contamination of room air and sewerage should not exceed the limits approved by the NRC as stated in 10 CFR 20 (found elsewhere in this Guide). When wastes exceed these limits, they shall be disposed of with the assistance of the Radiation Safety staff.

11. Radioactive Contaminated Equipment

The authorized physician is responsible for arranging for the safe disposal of all radioactive solutions and contaminated equipment such as syringes, etc. This may be accomplished by removal to the individual's laboratory for proper decontamination or storage for decay, or by contacting the Radiation Safety staff for disposal. Under no circumstances should such solutions or equipment be left on the nursing unit, or the responsibility for disposal of these materials be delegated to the nursing staff. The Radiation Safety Officer strongly recommends the use of

disposable syringes and needles for the administration of radionuclides. Disposable syringes containing only the usual residual fluid may be disposed of in the regular dry radioactive waste containers available on the nursing units. Disposable needles may also be put into the regular dry radioactive waste containers ONLY after they have been capped or after the needle point has been inserted in a small cork. This is necessary in order to preserve the integrity of the plastic bag lining the container and to protect personnel handling these liners.

12. Laboratory Specimens

There exists a danger that highly radioactive tissue specimens, blood, ascitic fluid, excreta, or cadavers may be delivered to the laboratory or pathology services, without being adequately labeled. To minimize this possibility, all specimens from such patients which are to be sent to a laboratory must be labeled "Radioactive." Preferably, the laboratory should be called in advance to give them additional information, such as the amount of activity and special handling techniques required, if any. This includes tissue specimens, ascitic fluid, blood, urine, feces, emesis, etc.

Exemptions:

(a) When the time elapsed between the administration of the radionuclide and the time of obtaining the specimen is such as to render the specimen (in the opinion of the physician in charge of the patient or in the opinion of the Radiation Safety Officer) no longer a hazard from either a health or a contamination standpoint.

(b) When the radionuclide is administered in such a way that it remains localized and does not enter significantly into the general circulation (such as colloidal gold injected into the prostate), and the specimen is excreta or a tissue removed at a site sufficiently distant from the injection site so that it is unlikely to contain any of the radioactive material.

13. Cadavers

If a patient who has received a therapeutic dose of any radionuclide dies in the hospital within a three (3) week period after that dose, the authorized physician is requested to do the following:

(a) Tie a radioactive hazard sign to the body writing on it the specific radionuclide amount given, and the date of administration.

(b) Place the Form PHS–412 as the top sheet in the chart and write across the face of this sheet "Radioactive Body."

(c) Notify the Radiation Safety Officer. During off-duty hours the Guard Office in Building 31 should be requested to notify one of the persons on the call list maintained for such emergencies. The Radiation Safety Officer must be notified as he is responsible for giving the pathologist suitable safety instructions and for giving the required information to the funeral director.

Procedures for Nursing and Patient Care Staff

1. Diagnostic Procedures

Since there is minimal external hazard to others from routine diagnostic doses of radionuclides, there are no restrictions on the patient's activities or his contacts with other people. Nursing personnel are not required to wear personnel monitoring devices.

The following procedures apply when a patient receives radioactive material for diagnostic purposes:

(a) The Chief Nurse of the unit should request a Geiger counter and dry radioactive waste can from the Radiation Safety staff to be kept in the utility room.

(b) Patient-care personnel should use disposable gloves to handle items suspected of contamination. Particular care should be exercised in the handling of vomitus and excreta during the first 24 hours following administration of the radionuclide. Use the Geiger counter to check for contamination. Contaminated linen should be placed in a yellow laundry bag which is kept in the patient's room. Other contaminated items should be placed in the radioactive waste container. Call the Radiation Safety Office for removal of such contaminated linen and waste.

(c) Laboratory samples taken during the first days post administration should be labeled "Radioactive," as per physicians orders.

(d) Special diagnostic procedures will be evaluated on an individual basis and appropriate written instructions may be issued.

(e) Should questions arise concerning the use of radionuclides on a unit, call the Radiation Safety staff for assistance.

2. Therapy Procedures

The following procedures apply when patients receive radionuclides other than sealed sources or colloi-

dal suspensions, in millicurie amounts for therapeutic purposes:

(a) Special Radiation Safety Procedures (Form NIH-88-7) will be issued to the Chief Nurse of the unit at the time the radionuclide is given or at the time the patient is returned from the operating room. This form will indicate precautions to be taken on a daily basis and will be reviewed each day by Radiation Safety personnel.

(b) A "Radiotherapy Precautions" sign shall be placed at the patient's door. Radiation Safety personnel will indicate when it may be removed.

(c) The patient should be put in a room by himself. For patients receiving gamma-emitting nuclides, this room should be as distant from the nursing station as feasible. *Exception*: Patients receiving radiation source implants (radium or iridium needles) or colloidal suspensions may be placed in a room with another patient providing this second patient is receiving external beam therapy.

(d) Handling of Patient

1. When indicated on the Form NIH-88-7, the patient-care staff should wear disposable gloves while handling the patient. Used gloves should be placed in the radioactive waste can for disposal.

2. Wash hands thoroughly with soap and running water after gloves are removed.

3. After handling the patient, patient-care personnel should monitor themselves thoroughly using the Geiger counter provided for this purpose.

(e) Food Service

If feasible, paper plates and disposable utensils should be used by the patient during therapy precautions. If found contaminated after use, they should be placed in the waste container provided for this purpose.

(f) Patient's Linen

All linen, i.e., bedclothes, pajamas, towels, etc., used during the period of therapy precautions must be placed in a yellow laundry bag to be kept in the patient's room, and must not be sent to the laundry until monitored by Radiation Safety personnel.

(g) Removal of Objects and Materials From Patient's Room

All objects or materials to be removed from the therapy precautions area shall be checked for contamination. It may be necessary to remove these articles temporarily to the utility room for monitoring, due to the radiation levels in the vicinity of the patient.

(h) Disposal of Radioactive Excreta

1. Feces should be passed in the toilet whenever possible. If a bedpan is used, it must be handled with disposable gloves. The same bedpan should be used until treatment is completed and its use restricted to that particular patient.

2. Urine shall be saved in stoppered bottles and if the radionuclide is a gamma-emitter, the bottles shall be kept in a shielded storage container provided by the Radiation Safety staff. Urine container, urinals, specimen bottles, etc., should be handled only by the patient if at all possible.

(i) Housekeeping Personnel

Housekeeping personnel shall not enter the room unless indicated on the Form NIH-88-7.

(j) Accidents

In case of an accident which might produce a radiation hazard (e.g., the spillage of contaminated urine on the floor)

CALL AT ONCE:

Weekdays, 7am-5pm --
- Physician in Charge
- Radiation Safety Br. (496-5774)
- Chief of Nursing Service

Evenings, weekends, holidays --
- Nursing Supervisor in Charge
- Physician in Charge
- Radiation Safety Br. (dial 116)

3. Colloidal Suspensions and Sealed Sources

The following apply when patients receive therapy utilizing colloidal suspensions or sealed sources, such as needles, tubes and plaques containing iridium-192, cobalt-60, radium, radon, etc.:

(a) All dressings, bedclothes, sanitary napkins, bedpans, etc., or any material removed from the vicinity of the treatment site shall be carefully monitored to assure that the source has not been removed or displaced.

(b) The above-mentioned items (a), (b), (c), and (i) of Part 2 shall also apply.

(c) Items (d), (e), (f), (g), and (h) do not apply to these cases since there is little if any chance of contamination.

(d) The nursing staff should be alert to any sealed sources which may have moved from their original positions. Should an implanted source become separated from the patient, proceed as in 2-(j) above.

Radiation Producing Equipment Operator's Responsibility

The operator of any radiation producing equipment is responsible for:

1. Notifying the Radiation Safety Office when there is any change in the setup, i.e., new equipment installed, changes in shielding, change in output of radiation, or change in usage of the unit.

2. Requesting and wearing appropriate monitoring devices. Always wear the assigned monitoring device (e.g., film badge) when working with the unit. Whenever protective lead aprons are worn, the body monitor should be worn on the outside of the apron at the neckline. In addition, wrist monitors are to be worn if the unprotected hands and forearms must come in close proximity to the beam.

3. Keeping exposure as low as possible. The operator must never expose himself to the direct beam, and must not stand within one meter of the tube or irradiated target while the unit is in operation unless adequately shielded. Make full use of protective barriers, lead aprons, gloves, and goggles.

4. Clearing the area of all nonessential personnel. The operator should insist that all nonessential personnel leave the exposure area before operating the unit, and that all essential personnel be adequately shielded.

5. Observing any restrictions on the use of the unit recommended by the Radiation Safety staff.

6. Adequate dark adaptation. The eyes of the fluoroscopist should be well dark-adapted before he uses a fluoroscope without image intensifying equipment. It is inexcusable to increase the output of the unit to compensate for poor dark adaptation.

7. Using minimum exposure factors. Fluoroscopic work shall be performed in the minimum time possible using the lowest dose rate and smallest aperture consistent with clinical requirements.

8. Visually monitoring tube current and potential of fluoroscopic equipment with image intensifiers at frequent intervals, because under automatic brightness control these variables can rise to high values.

9. Recording data of fluoroscopic and cineradiographic studies on patients on Form NIH-378, "Radiation Exposure Record," and maintaining this form in the patient's record.

10. Notifying the supervisor and the Radiation Safety Officer immediately of any accidental exposures to radiation.

11. Keeping the unit disconnected or locked when not in actual use.

Policies for Radiation Producing Machines and Areas

1. All operating personnel and personnel in the immediate area will be required to wear a film badge or other personnel monitoring device.

2. Areas in which radiation producing machines are located or are being used shall be posted with the characteristic "CAUTION RADIATION" sign. In addition, the controls shall bear a decal with the statement: "CAUTION RADIATION. This equipment produces radiation when energized." Labels and decals are available from the Radiation Safety Office.

> Exception: Diagnostic and patient treatment areas need not be so marked, provided that a person is charged with the responsibility for protection of employees, patients, and authorized visitors against radiation injuries, and for the execution of Radiation Safety recommendations.

3. The structural shielding requirements of any new installation, or an existing one in which changes are contemplated, shall be discussed with the Radiation Safety staff.

4. An annual, scheduled survey of all radiation producing equipment used on patients shall be made by Radiation Safety personnel. In addition, radiation surveys will be made of all new installations and all existing installations after every change that might increase the radiation hazard (e.g., replacement of x-ray tube, changes in filtration of beam).

5. Unless measurements indicate that they are not needed, protective aprons shall be worn by the physician, nurse, technician, and all other persons within the room or area who are frequently or habitually exposed to radiation.

6. Dose rates for the beam shall be determined for all units used on human subjects and will be reported to the operator in milliroentgens per milliampere-second or milliroentgens per minute. The "Radiation Exposure Record," Form NIH-378, shall be completed for fluoroscopic and cineradiographic studies and maintained in the patient's record.

7. In the operation of mobile and dental units:

(a) The operator should stand as far as possible from the tube and patient during exposure, and should wear a protective apron, or step behind an adequate shield.

(b) An operator, standing at least 6 feet from the tube and patient, should not make more than 5,000 milliampere-seconds of exposure during any one week. Rotation of operators or the use of portable shields is recommended for greater workloads.

8. The hand of the fluoroscopist should never be placed in the useful beam unless the beam is attenuated by the patient and a protective glove of at least 0.25 mm lead equivalent is worn.

9. No person shall be regularly employed to hold patients during exposure, nor shall anyone from the Diagnostic Radiology Department ever be permitted to perform such service. The person holding the patient shall wear protective gloves and a protective apron. No part of this person's body should be in the unattenuated useful beam.

10. If safe use of the installation depends upon mechanical restriction of the orientation of the radiation beam, or upon limitations (voltage, current, time, permanent filter, and maximum aperture) in the output of the unit, then these restrictions shall be rigidly followed.

11. Shutter mechanisms and interlocking devices should not be tampered with and shall be inspected at frequent intervals to insure proper operation.

12. All protective devices that may become defective due to use or abuse, such as protective lead aprons or gloves, should be inspected for radiation leakage at least every six months, or whenever the integrity of the equipment is suspect.

13. A manually reset cumulative timing device shall be used which will either indicate elapsed time or turn off the apparatus when the total exposure reaches a certain previously determined limit.

14. In cineradiography, tube currents and potentials are often higher than those used in fluoroscopy. Thus, special care should be taken to limit patient exposure. The exposure rates on these cineradiography units shall be determined during the annual survey.

15. X-ray diffraction equipment can be particularly hazardous because of high exposure rates in the primary beam (e.g., in excess of 500,000 roentgens per minute at the x-ray tube port).

(a) A radiation survey shall be made by the Radiation Safety staff before a new installation is placed in routine operation and whenever changes are made which could adversely affect radiation protection. The equipment shall be frequently inspected for radiation leakage and a radiation survey shall be made at least annually by Radiation Safety personnel.

(b) Appropriate operating procedures and safety measures approved by the Radiation Committee shall be established and followed for these units.

16. Personnel specifically responsible for such equipment shall insure that all workers in the area are monitored in accordance with the requirements for the specific unit.

17. For larger, individually licensed irradiators and accelerators, specific operating and emergency procedures shall be established and posted. All users of this equipment shall operate it in compliance with these posted instructions.

18. All interlocks, visual and audible warning devices, and monitoring equipment shall be inspected for proper operation at six month intervals by Radiation Safety personnel.

Procurement of Radiation Sources

The following procedures for the procurement of radiation sources are intended to insure compliance with the terms and conditions of the license issued by NRC, and the regulations imposed by the Director, NIH.

1. The Radiation Safety Officer must be notified in advance of the procurement of all radiation sources whether ionizing radiation producing machines, NRC licensable or accelerator-produced radionuclide, radium, or other radioactive materials.

2. When the use of radiation sources is planned the investigator must indicate to the Radiation Committee his training and experience in this area. This is done by submitting one copy of the Form NIH-88-2 "Application for Use of Radioisotopes at the National Institutes of Health" to the Radiation Safety Office. When the investigator makes application to the Committee, it is understood that *he accepts the responsibility for complying with the regulations governing the safe use of sources in NIH controlled areas.*

3. Upon notification of approval of his qualifications, the investigator then submits Form NIH-88-1, "Request for Purchase and Use of Radionuclides," to the Radiation Safety Office. The form covers only the quantities specified on a single requisition. The form must be completed regardless of the method of acquisition. In cases other than purchase, the form serves as the required notice to the Radiation Safety Office that the receipt of radioactive materials is contemplated through gifts or transfers from any source.

4. Established users of the NIH license may procure radionuclides under the Telephone Charge Order (TCO) system, provided all conditions of the Small Purchase Procedures Manual (NIH Manual Handbook 2600-103-26.9) are met. Authorized investigators are reminded that: the dollar limit for radionuclides is $500 and for radionuclides being used under the NIH Broad License delivery must be made within ten (10) days to: *Radiation Safety Officer, National Institutes of Health, Building 21, Radionuclide Laboratory, Bethesda, Maryland 20014.* See Small Purchase Procedures Manual for step-by-step instructions for obtaining radionuclides by TCO and for list of TCO Account Suppliers.

5. Purchase orders exceeding $500 will be requisitioned in the usual manner by using Form PHS-402-1, "Requisition for Equipment and Supplies," which shall be clearly labeled *"Radionuclide Order."* The requisition must be completed in all normal respects and, in addition, specify that delivery be made to the *Radiation Safety Officer, National Institutes of Health, Building 21, Radionuclide Laboratory, Bethesda, Maryland 20014.* The requisition and accompanying Form NIH-88-1 are routed through Radiation Safety, Bldg. 21, to the Procurement Section, Bldg. 13.

6. The purchase order will then be prepared by the Procurement Section, Material Management, and routed through the Radiation Safety Office for final approval. The Radiation Safety Officer will indicate approval and place the NRC license number on the purchase order and forward it to the supplier.

7. The Radiation Safety Office will be the receiving point on the NIH reservation for such material and will make the actual delivery to the ordering investigator. Any changes in the original shipping instructions should be furnished to this office by the investigator or the Institute ordering office serving him. Shipping information received from the supplier by the Procurement Section and the Receiving Control Reports Section, Bldg. 13, will be furnished immediately to the Radiation Safety Office which in turn will keep the ordering investigator properly informed.

8. In the case of ionizing radiation producing machines such as x-ray units, linear accelerators, etc., the notification is made on Form NIH-88-1, "Request for Authorization to Purchase and Use Radiation Producing Machinery or Equipment." The filing of Training and Experience Form NIH-88-2 may or may not be required by the Radiation Committee depending on the device(s), its complexity and the proposed uses. Consult with the Radiation Safety Officer concerning this Training and Experience requirement. The equipment is then requisitioned in the usual manner using Form PHS-402-1.

Shipping Radioactive Materials

1. When radioactive material is to be shipped from NIH, the shipper must notify the Radiation Safety Office instead of the Shipping and Receiving Section. The Radiation Safety staff will pick up these shipments on telephone request. The usual NIH shipping request Form NIH 1884 is to be prepared and will accompany the container. Under item 7 of this form the description of articles must include radionuclide, chemical form, and activity (in μCi or mCi).

2. The recipient of any material to be shipped from NIH must provide evidence of an NRC (or agreement state*) license by furnishing a copy of his license to the Radiation Safety Office before shipment can be made. Noncompliance with this requirement is a violation of the Atomic Energy Act and is subject to criminal prosecution as well as denial to NIH of further NRC-controlled radionuclides. Check first with the Radiation Safety staff by phone to see if the recipient's license is already on file. If not, then request a copy from the recipient in order to fulfill this requirement.

3. The investigator is reminded that the NIH specific license of broad scope *covers only the Bethesda reservation, Auburn Building and the Danac Buildings (4 and 5) in Rockville*. Materials transported by the investigator to other installations must be transferred to the respective licensees in that area as in paragraph 2 above and in a manner complying with applicable NRC and/or Department of Transportation regulations.

4. When an empty radionuclide container is to be returned to the supplier, the ordering investigator must notify the Radiation Safety Office, who will certify that it is free of contamination. The container may then be returned through normal channels. Promptness in returning the container is urged. Conditions of purchase usually require that such containers will be returned within a specified period of time.

*Agreement States. Those states that have entered into agreements with the NRC for the control of radioactive material.

Off-Site Use of Radionuclides by NIH Staff

As specified in NIH Manual Issuance 1344, NIH investigators working with radioactive materials and radiation producing devices will comply with the following:

1. All off-site† uses of radionuclides, domestic or foreign, under "generally licensed quantities" (10 CFR 31.100) or individual NRC or agreement state license should be subject to the same scientific review and approval by the Radiation Committee as prevails for in-house use.

2. Off-site domestic use under various forms of NRC or agreement state license of an NIH scientist may be permitted. This requires approval of the same type of application as is required for NIH use, plus approval of the application form as submitted to NRC or the agreement state, including specific data with respect to proposed methods of compliance with 10 CFR, Parts 19 and 20 or similar agreement state regulations. The NIH Radiation Safety Office will provide assistance with these applications and requires copies of all relevant correspondence, of the final licenses, of renewals, and of subsequent amendments to the licenses.

3. Off-site foreign use may be authorized following compliance with paragraph (1) and receipt by the Radiation Committee of an acceptable statement indicating the full knowledge and agreement of an appropriate authority in the host country.

4. All NIH scientists using radionuclides under any circumstances in off-site locations, domestic or foreign, must use NIH personnel monitoring devices when indicated or be under an equivalent monitoring program acceptable to and reporting to the NIH Radiation Safety Office.

5. The NIH Radiation Committee and Radiation Safety Office are authorized to intervene and apply the applicable NIH regulations to off-site uses of other sources of ionizing radiations employed by NIH personnel.

6. Users of radionuclides authorized and procured under the NIH Broad NRC License are reminded that this license is specific for the NIH *Bethesda reservation, Auburn Building, Danac Buildings 4 and 5, and other buildings specifically mentioned in amendments to the NIH Broad License*. This means that the transfer of radionuclides from these locations to off-site premises requires clearance through the NIH Radiation Safety Office. Transfers of radionuclides from off-site locations to NIH must be made in accordance with the requirements of "Procurement of Radiation Sources."

†Off-site: All research locations other than the NIH reservation, the Auburn Building (Bethesda) and Danac Buildings 4 and 5 (Rockville) where NIH personnel are assigned.

Glossary

ABSORBED DOSE: The amount of energy imparted to matter by ionizing radiation per unit mass of irradiated material. (See Rad)

ABSORPTION: The phenomenon by which radiation imparts some or all of its energy to any material through which it passes.

ACTIVITY: The number of nuclear disintegrations occurring in a given quantity of material per unit time. (See Curie)

ALPHA PARTICLE: A strongly ionizing particle emitted from the nucleus during radioactive decay having a mass and charge equal in magnitude to a helium nucleus, consisting of 2 protons and 2 neutrons with a double positive charge.

ALPHA RAY: A stream of fast-moving helium nuclei (alpha particles), a strongly ionizing and weakly penetrating radiation.

ANNIHILATION (Electron): An interaction between a positive and negative electron; their energy, including rest energy, being converted into electromagnetic radiation (annihilation radiation).

ATOM: Smallest particle of an element which is capable of entering into a chemical reaction.

AUTORADIOGRAPH: Record of radiation from radioactive material in an object, made by placing the object in close proximity to a photographic emulsion.

BACKGROUND RADIATION: Ionizing radiation arising from radioactive material other than the one directly under consideration. Background radiation due to cosmic rays and natural radioactivity is always present. There may also be background radiation due to the presence of radioactive substances in other parts of the building, in the building material itself, etc.

BETA PARTICLE: Charged particle emitted from the nucleus of an atom, having a mass and charge equal in magnitude to that of the electron.

BETA RAY: A stream of high speed electrons or positrons of nuclear origin more penetrating but less ionizing than alpha rays.

BREMSSTRAHLUNG: Electromagnetic (x-ray) radiation associated with the deceleration of charged particles passing through matter. Usually associated with energetic beta emitters, e.g., phosphorus-32.

CALIBRATION: Determination of variation from standard, or accuracy, of a measuring instrument to ascertain necessary correction factors.

CONTAMINATION, RADIOACTIVE: Deposition of radioactive material in any place where it is not desired, and particularly in any place where its presence may be harmful. The harm may be vitiating the validity of an experiment or a procedure, or in actually being a source of excessive exposure to personnel.

CARRIER FREE: An adjective applied to one or more radionuclides of an element in minute quantity, essentially undiluted with stable isotope carrier.

COUNT (Radiation Measurements): The external indication of a device designed to enumerate ionizing events. It may refer to a single detected event or to the total registered in a given period of time. The term is often erroneously used to designate a disintegration, ionizing event, or voltage pulse.

CRITICAL ORGAN: That organ or tissue, the irradiation of which will result in the greatest hazard to the health of the individual or his descendants.

CURIE: The quantity of any radioactive material in which the number of disintegrations is 3.700×10^{10} per second. Abbreviated Ci.

Millicurie: One-thousandth of a curie (3.7×10^{7} disintegrations per second). Abbreviated mCi. Microcurie: One millionth of a curie (3.7×10^{4} disintegrations per second). Abbreviated μCi. Picocurie: One millionth of a microcurie (3.7×10^{-2} disintegrations per second or 2.22 disintegrations per minute). Abbreviated pCi.

DECAY, RADIOACTIVE: Disintegration of the nucleus of an unstable nuclide by the spontaneous emission of charged particles and/or photons.

DOSE: A general term denoting the quantity of radiation or energy absorbed in a specified mass. For special purposes it must be appropriately qualified, e.g., absorbed dose.

DOSE, ABSORBED: The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The unit of absorbed dose is the rad, which is 100 ergs/gram.

DOSE EQUIVALENT: A quantity used in radiation protection expressing all radiation on a common scale for calculating the effective absorbed dose. The unit of dose equivalent is the rem, which is numerically equal to the absorbed dose in rads multiplied by certain modifying factors such as the quality factor, the distribution factor, etc.

EFFICIENCY (Counters): A measure of the probability that a count will be recorded when radiation is incident on a detector. Usage varies considerably so it is well to make sure which factors (window, transmission, sensitive volume, energy dependence, etc.) are included in a given case.

ELECTRON: Negatively charged elementary particle which is a constituent of every neutral atom. Its unit of negative electricity equals 4.8×10^{-10} coulombs. Its mass is 0.00549 atomic mass units.

ELECTRON CAPTURE: A mode of radioactive decay involving the capture of an orbital electron by its nucleus. Capture from the particular electron shell is designated as "K-electron capture," "L-electron capture," etc.

ELECTRON VOLT: A unit of energy equivalent to the amount of energy gained by an electron in passing through a potential difference of 1 volt. Abbreviated eV. Larger multiple units of the electron volt frequently used are: keV for thousand or kiloelectron volts, MeV for million electron volts and BeV for billion electron volts.

EXPOSURE: A measure of the ionization produced in air by x or gamma radiation. It is the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of air in the volume element. The special unit of exposure is the roentgen.

FILM BADGE: A packet of photographic film used for the approximate measurement of radiation exposure for personnel monitoring purposes. The badge may contain two or more films of differing sensitivity, and it may contain filters which shield parts of the film from certain types of radiation.

FILTER (Radiology), PRIMARY: A sheet of material, usually metal, placed in a beam of radiation to remove, as far as possible, the less penetrating components of the beam. **SECONDARY**: A sheet of material of lower atomic number, relative to that of the primary filter, placed in the filtered beam of radiation to remove characteristic radiation produced by the primary filter.

GAMMA RAY: Very penetrating electromagnetic radiation of nuclear origin. Except for origin, identical to x-ray.

GEIGER-MUELLER (G-M) COUNTER: Highly sensitive gas filled detector and associated circuitry used for radiation detection and measurement.

GENETIC EFFECT OF RADIATION: Inheritable changes, chiefly mutations, produced by the absorption of ionizing radiations. On the basis of present knowledge these effects are purely additive, and there is no recovery.

HALF-LIFE, BIOLOGICAL: The time required for the body to eliminate one-half of an administered dose of any substance by the regular processes of elimination. This time is approximately the same for both stable and radionuclides of a particular element.

HALF-LIFE, EFFECTIVE: Time required for a radioactive nuclide in a system to be diminished 50 percent as a result of the combined action of radioactive decay and biological elimination.

$$\text{Effective half-life} = \frac{\text{Biological half-life} \times \text{Radioactive half-life}}{\text{Biological half-life} + \text{Radioactive half-life}}$$

HALF-LIFE, RADIOACTIVE: Time required for a radioactive substance to lose 50 percent of its activity by decay. Each radionuclide has a unique half-life.

HALF VALUE LAYER (Half thickness): The thickness of any specified material necessary to reduce the intensity of an x-ray or gamma ray beam to one-half its original value.

HEALTH PHYSICS: A term in common use for that branch of radiological science dealing with the protection of personnel from harmful effects of ionizing radiation.

INVERSE SQUARE LAW: The intensity of radiation at any distance from a point source varies inversely as the square of that distance. For example: If the radiation exposure is 100 R/hr at 1 inch from a source, the exposure will be 0.01 R/hr at 100 inches.

ION: Atomic particle, atom, or chemical radical bearing an electrical charge, either negative or positive.

IONIZATION: The process by which a neutral atom or molecule acquires either a positive or a negative charge.

IONIZATION CHAMBER: An instrument designed to measure the quantity of ionizing radiation in terms of the charge of electricity associated with ions produced within a defined volume.

IONIZATION, SPECIFIC: The number of ion pairs per unit length of path of ionizing radiation in a medium, e.g., per centimeter of air or per micron of tissue.

IONIZING RADIATION: Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.

ISOTOPES: Nuclides having the same number of protons in their nuclei, and hence having the same atomic number, but differing in the number of neutrons, and therefore in the mass number. Almost identical chemical properties exist between isotopes of a particular element.

LABELED COMPOUND: A compound consisting, in part, of labeled molecules. By observations of radioactivity or isotopic composition this compound or its fragments may be followed through physical, chemical or biological processes.

MAXIMUM PERMISSIBLE DOSE (MPD): Maximum dose of radiation which may be received by persons working with ionizing radiation, which will produce no detectable damage over the normal life span.

MILLIROENTGEN (mR): A submultiple of the roentgen equal to one one-thousandth (1/1000th) of a roentgen. (See Roentgen).

MONITORING, RADIOLOGICAL: Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in an occupied region as a safety measure for purposes of health protection.

Area Monitoring: Routine monitoring of the level of radiation or of radioactive contamination of any particular area, building, room or equipment.

Personnel Monitoring: Monitoring any part of an individual, his breath, excretions, or any part of his clothing. (See Radiological Survey).

NEUTRON: Elementary particle with a mass approximately the same as that of a hydrogen atom and electrically neutral. It has a half-life in minutes and decays in a free state into a proton and an electron.

NUCLIDE: A species of atom characterized by its mass number, atomic number, and energy state of its nucleus, provided that the atom is capable of existing for a measurable time.

PROTECTIVE BARRIERS: Barriers of radiation absorbing material, such as lead, concrete, plaster, and plastic, that are used to reduce radiation exposure.

Protective Barriers, Primary: Barriers sufficient to attenuate the useful beam to the required degree.

Protective Barriers, Secondary: Barriers sufficient to attenuate stray or scattered radiation to the required degree.

RADIATION: 1. The emission and propagation of energy through space or through a material medium in the form of waves, for instance, the emission and propagation of electromagnetic waves, or of sound and elastic waves. 2. The energy propagated through a material medium as waves, for example, energy in the form of electromagnetic waves or of elastic waves. The term "radiation" or "radiant energy," when unqualified, usually refers to electromagnetic radiation. Such radiation commonly is classified according to frequency as Hertzian, infrared, visible (light), ultraviolet, x-ray, and gamma ray. 3. By extension, corpuscular emissions, such as alpha and beta radiation, or rays of mixed or unknown type, as cosmic radiation.

RADIOLOGICAL SURVEY: Evaluation of the radiation hazards incident to the production, use or existence of radioactive materials or other sources of radiation under a specific set of conditions. Such evaluation customarily includes a physical survey of the disposition of materials and equipment, measurements or estimates of the levels of radiation that may be involved, and a sufficient knowledge of processes using or affecting these materials to predict hazards resulting from expected or possible changes in materials or equipment.

RADIONUCLIDE: A nuclide with an unstable ratio of neutrons to protons placing the nucleus in a state of stress. In an attempt to reorganize to a more stable state, it may undergo various types of rearrangement that involve the release of radiation.

RADIOTOXICITY: Term referring to the potential of an isotope to cause damage to living tissue by absorption of energy from the disintegration of the radioactive material introduced into the body.

RELATIVE BIOLOGICAL EFFECTIVENESS (RBE): For a particular living organism or part of an organism, the ratio of the absorbed dose of a reference radiation that produces a specified biological effect to the absorbed dose of the radiation of interest that produces the same biological effect.

REM: The special unit of dose equivalent. The dose equivalent in rems is numerically equal to the absorbed dose in rads multiplied by the quality factor, distribution factor, and any other necessary modifying factors.

ROENTGEN (R): The quantity of x- or gamma radiation such that the associated corpuscular emission per 0.001293 grams of dry air produces, in air, ions carrying one electrostatic unit of quantity of electricity of either sign. The roentgen is the special unit of exposure.

SCINTILLATION COUNTER: A counter in which light flashes produced in a scintillator by ionizing radiation are converted into electrical pulses by a photomultiplier tube.

SHIELDING MATERIAL: Any material which is used to absorb radiation and thus effectively reduce the intensity of radiation, and in some cases eliminate it. Lead, concrete, aluminum, water, and plastic are examples of commonly used shielding material.

SMEAR (Smear or Swipe Test): A procedure in which a swab, e.g., a circle of filter paper, is rubbed on a surface and its radioactivity measured to determine if the surface is contaminated with loose radioactive material.

SPECIFIC ACTIVITY: Total radioactivity of a given nuclide per gram of a compound, element or radioactive nuclide.

TRACER, ISOTOPIC: The isotope or nonnatural mixture of isotopes of an element which may be incorporated into a sample to make possible observation of the course of that element, alone or in combination, through a chemical, biological, or physical process. The observations may be made by measurement of radioactivity or of isotopic abundance.

THERMOLUMINESCENT DOSIMETER: A dosimeter made of certain crystalline material which is capable of both storing a fraction of absorbed ionizing radiation and releasing this energy in the form of visible photons when heated. The amount of light released can be used as a measure of radiation exposure to these crystals.

X-RAYS: Penetrating electromagnetic radiations having wave lengths shorter than those of visible light. They are usually produced by bombarding a metallic target with fast electrons in a high vacuum. In nuclear reactions it is customary to refer to photons originating in the nucleus as gamma rays, and those originating in the extranuclear part of the atom as x-rays. These rays are sometimes called roentgen rays after their discoverer, W. C. Roentgen.

GUIDELINES FOR MAXIMUM PERMISSIBLE DOSES FOR NIH PERSONNEL

Organ	Dose in mrem			
	Year	Quarter	Month	Week
Whole Body (Including Gonads, Lens of Eye, Red Bone Marrow)	5,000	1,250	400	100
Forearms, Hands, Feet and Ankles	75,000	18,750	6,250	1,500
Skin of Whole Body	30,000	7,500	2,500	650
Fertile Age Women*	3,000		250	60
Pregnant Women or Employees Under 18 Years of Age*	500	125	40	10

For information on specific organs or tissues not listed, consult with Radiation Committee or Radiation Safety Officer.

* The National Council on Radiation Protection and Measurements, in Report No. 39, recommends a maximum permissible dose of 2 to 3 rem per year, at an even rate. Also see U.S. Nuclear Regulatory Commission Guide 8.13 in the Appendix.

CLASSIFICATION OF RADIONUCLIDES ACCORDING TO RELATIVE RADIOACTIVITY PER UNIT ACTIVITY

(Based on Published Data and NIH User Experience)

Class 1 (very high toxicity)
Sr-90 + Y-90, *Pb-210 + Bi-210(Ra D + E), Po-210, At-211, *Ra-226 + 55% *daughter products, Ac-227, *U-233, Pu-239, *Am-241, Cm-242, plus other transuranium isotopes.

Class 2 (high toxicity)
Ca-45, *Ca-47, *Fe-59, *Sr-85, Sr-89, Y-91, *Ru-106 + Rh-106, *I-125, *I-131, *Ba-140 + *La-140, Ce-144 + *Pr-144, Sm-151, *Eu-154, *Tm-170, *Hg-203, *Th-234 + *Pa-234, *natural uranium.

Class 3 (moderate toxicity)
*Na-22, *Na-24, P-32, P-33, S-35, Cl-36, *K-42, *Sc-46, *Sc-47, *Sc-48, *V-48, *Mn-52, *Mn-54, *Mn-56, Fe-55, *Co-57, *Co-58, *Co-60, Ni-59, *Cu-64, *Cu-67, *Zn-65, *Ga-67, *Ga-72, *As-74, *As-76, *Br-82, *Kr-85, *Rb-84, *Rb-86, *Zr-95 + *Nb-95, *Nb-95, *Mo-99, Tc-98, *Rh-105, Pd-103 + Rh-103, *Ag-105, *Ag-111, Cd-109 + *Ag-109, *Sn-113, *Te-127, *Te-129, *I-132, *Xe-133, *Cs-137 + *Ba-137, *La-140, Pr-143, Pm-147, *Ho-166, *Lu-177, *Ta-182, *W-181, *Re-183, Ir-190, *Ir-192, Pt-191, *Pt-193, *Au-196, *Au-198, *Au-199, Tl-200, Tl-202, Tl-204, *Pb-203, *Hg-197.

Class 4 (slight toxicity)
H-3, Be-7, C-14, *F-18, *Cr-51, Ge-71, *Sr-87m, *Tc-99m, *Tl-201.

*Gamma emitter and/or associated photon emitter.

GUIDELINES FOR MAXIMUM ACTIVITIES IN NIH LABORATORIES

Radiotoxicity of Radionuclides	Minimum Significant Quantity Utilized	Typical NIH Laboratory	Radionuclide Laboratory Building 21 (1)
Very high	0.1 μCi	10 μCi or less	10 μCi–10 mCi
High	1.0 μCi	100 μCi or less	100 μCi–100 mCi
Moderate	10 μCi	1 mCi or less	1 mCi–1 Ci
Slight	100 μCi	10 mCi or less	10 mCi–10 Ci

Modifying factors should be applied to the quantities indicated in the last 2 columns of the above table, according to the complexity of the procedures to be followed. The following factors are suggested but due regard should be paid to the circumstances affecting individual cases.

Procedure	*Modifying factor*
Storage (stock solutions)	× 100
Very simple wet operations	× 10
Normal chemical operations	× 1
Complex wet operations with risk of splits	× 0.1
Simple dry operations	× 0.1
Dry and dusty operations	× 0.01

(1) With proper documentation of experimental protocol and with approval of the Radiation Committee, investigators may be permitted to use these quantities in NIH laboratories outside Building 21. With similar documentation, activities exceeding these maximum quantities may be approved for use in Building 21 only.

SELECTED PROPERTIES OF MOST FREQUENTLY ORDERED RADIONUCLIDES

Nuclide	Maximum Beta Energy (MeV)	Gamma Energy (MeV)	Γ_γ mR/hr/mCi at 1 m	Critical organ	MPB (μCi)	Half-Life	
						Radioactive	Biological (days)
^{3}H	0.0186			Body Tissue	2000	12.26y	12
^{14}C	0.156			Body Fat	180	5730y	12
^{24}Na	1.389	1.369 (100%) 2.754 (100%)	1.84	Total Body	7	14.96h	11
^{32}P	1.710			Bone	3	14.28d	1155
^{33}P	0.248			Bone	32	24.4d	1155
^{35}S	0.167			Testis Total Body	0.18 400	87.9d	623
^{51}Cr		0.32(9%)	0.016	Total Body	1100	27.8d	616
^{125}I		28 keV average (143%)	0.07	Thyroid	0.57	60.1d	138
^{131}I	0.606	0.637 (6.8%) 0.364 (82%)	0.22	Thyroid	0.078	8.05d	138

Column (4), Γ_γ Milliroentgens per hour at 1 meter from 1 millicurie.

Column (5), Critical organ. The organ that receives the limiting dose equivalent from a substained burden (see discussion of Column 6). These organs are chosen based on the way in which the radioactive material is distributed within the body after intake.

Column (6), Maximum Permissible Burden (MPB). The amount of a radionuclide in an organ which, when sustained in that organ continuously, would produce the maximum permissible dose equivalent. The corresponding maximum permissible dose equivalents for the organs above are: body fat and thyroid, 15 rem/yr, and all others 5 rem/yr.

Column (7), Radioactive Half-Life. Present best value, obtained from "Table of Isotopes—6th Edition" by C. M. Lederer, J. M. Hollander, and I. Perlman, John Wiley & Sons, New York, 1967. The abbreviations used here are: s, second; m, minute; h, hour; d, day; and y, year.

Column (8), Biological Half-Life. The time required for one-half of the stable element to be removed from the critical organ by biological processes, as listed by the ICRP. The actual half-life of elimination depends also on the half-life of the isotope. The "effective half-life" in the critical organ (T_{eff}) is given by $T_{eff} = \frac{T_r T_b}{T_r + T_b}$ where T_r is the radioactive half-life and T_b is the biological half-life.

Rules of Thumb

Beta Particles

a. Beta particles of at least 70 keV energy are required to penetrate the nominal protective layer of the skin (7 mg/cm² or 0.07 mm).

b. The average energy of a beta-ray spectrum is approximately one-third the maximum energy.

c. The range of beta particles in air is ~ 12 ft/MeV. (Maximum range of ^{32}P beta is 1.71 MeV × 12 ft/Mev ≈ 20 ft).

d. The dose rate in rads per hour in a solution by a beta emitter is 1.12 EC/ρ, where E is the average beta energy per disintegration in MeV, C is the concentration in microcuries per cubic centimeter, and ρ is the density of the medium in grams per cubic centimeter. The dose rate at the surface of the solution is one-half the value given by this relation. (For ^{32}P average energy of approximately 0.7 MeV, the dose rate from 1 μCi/cm² (in water) is 1.48 rads/hr).

e. The surface dose rate through the nominal protective layer of skin (7 mg/cm²) from a uniform thin deposition of 1 μCi/cm² is about 9 rads/hour for energies above about 0.6 MeV. Note that in a thin layer, the beta dose rate exceeds the gamma dose rate, for equal energies released, by about a factor of 100.

f. For a point source of beta radiation (neglecting self and air absorption) of strength mCi millicuries, the dose rate at 1 cm is approximately equal to 200 × mCi rads/hour and varies only slowly with beta energy. Dose rate for 1 mCi ^{32}P at 1 cm is approximately 200 rads/hour.

Gamma Rays

a. For a point source gamma emitter with energies between 0.07 and 4 MeV, the exposure rate (mR/hr) within ± 20% at 1 foot is 6 × mCi × E × n, where mCi is the number of millicuries; E, the energy in MeV; and n, the number of gammas per disintegration.

b. The dose rate to tissue in rads per hour in an infinite medium uniformly contaminated by a gamma emitter is 2.12 EC/ρ, where C is the number of microcuries per cubic centimeter, E is the average gamma energy per disintegration in MeV, and ρ is the density of the medium. At the surface of a large body, the dose rate is about half of this.

X-Ray

a. The exposure rate at 2 feet from diagnostic x-ray equipment operated at 100 kVp and 100 milliamperes is approximately 2.3 roentgens/second.

b. Exposure rate at the fluoroscopy table with tube potential at 80 kVp and tube current of 1 milliampere should not exceed 2.1 roentgens/minute.

c. Scattered radiation can be as penetrating as the primary beam.

X-Ray Diffraction

a. The x-ray beam intensities from the primary beam can be as much as 400,000 R/min.

b. Scattered radiation 10 cm from the points of scatter about the x-ray tube head has been measured in the order of 150 R/hr.

c. The threshold dose sufficient to produce skin erythema is 300 to 400 roentgens.

d. The minimum cataractogenic single dose is 200 rads, while a dose of 750 rads exhibits a high incidence of cataract formation.

Miscellaneous

a. The activity of any radionuclide is reduced to less than 1% after 7 half-lives (i.e., $2^{-7} \approx 0.8\%$).

b. For material with a half-life greater than six days, the change in activity in 24 hours will be less than 10%.

U.S.C. 5841); 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), (c), (d), and (e) and 19.13 are issued under sec. 161(b), 68 Stat. 948, as amended (42 U.S.C. 2201(b)); and §§ 19.13 and 19.14(a) are issued under sec. 161(o), 68 Stat. 950, as amended (42 U.S.C. 2201(o)).

SOURCE: 38 FR 22217, Aug. 17, 1973, unless otherwise noted.

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

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19.17 Inspections not warranted; informal review.
19.20 Employee protection.
19.30 Violations.
19.31 Application for exemptions.
19.32 Discrimination prohibited.

AUTHORITY: Secs. 53, 63, 81, 103, 104, 161, 186, 68 Stat. 930, 933, 935, 938, 937, 948, 955, as amended, sec. 234, 83 Stat. 444, as amended (42 U.S.C. 2073, 2093, 2111, 2133, 2134, 2201, 2236, 2282); sec. 201, 88 Stat. 1242, as amended by Pub. L. 94-79, 89 Stat. 413 (42

§ 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.

[40 FR 8783, Mar. 3, 1975]

§ 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, 40, 60, 61, 70 or Part 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.

[46 FR 58282, Dec. 1, 1981, as amended at 47 FR 57478, Dec. 27, 1982]

§ 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) "License" means a license issued under the regulations in Parts 30 through 35, 40, 60, 61, 70, or Part 72 of this chapter, including licenses to operate a production or utilization facility pursuant to Part 50 of this chapter and licenses 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.

[38 FR 22217, Aug. 17, 1973, as amended at 40 FR 8783, Mar. 3, 1975; 46 FR 58282, Dec. 1, 1981; 47 FR 57478, Dec. 27, 1982]

§ 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.

[40 FR 8783, Mar. 3, 1975]

§ 19.8 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 3150-0044.

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

[49 FR 19624, May 9, 1984]

§ 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 6-82 or later) "Notice to Employees," as required by Parts 30, 40, 50, 60, 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 5 working days or until action correcting the violation has been completed, whichever is later.

[38 FR 22217, Aug. 17, 1973, as amended at 40 FR 8783, Mar. 3, 1975; 47 FR 30454, July 14, 1982]

§ 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 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 regulation 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 § 20.405 or § 20.408 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.

[38 FR 22217, Aug. 17, 1973, as amended at 40 FR 8783, Mar. 3, 1975; 44 FR 32352, June 6, 1979]

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

(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 § 19.15. 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 license, 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 inspectors, 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 license 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, to the Administrator 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 Administrator, 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 Administrator 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 pursuant to this section need not be limited to matters referred to in the complaint.

[38 FR 22217, Aug. 17, 1973, as amended at 40 FR 8783, Mar. 3, 1975; 47 FR 30454, July 14, 1982]

§ 19.17 Inspections not warranted; informal review.

(a) If the Director of the Office of Inspection and Enforcement or the Administrator 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 Operation, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, who will provide the licensee with a copy of such statement by certified mail, excluding, 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, modifying, or reverse the determination of the Director of the Office of Inspection and Enforcement or the Administrator of the appropriate Regional Office and furnish the complainant and the licensee a written notification of his decision and the reason therefor.

(b) If the Director of the Office of Inspection and Enforcement or the Administrator 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).

[38 FR 22217, Aug. 17, 1973, as amended at 40 FR 8783, Mar. 3, 1975]

§ 19.20 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 30, 40, 50, 60, 70, 72, or 150 of this chapter is prohibited.

[47 FR 30454, July 14, 1982]

§ 19.30 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, 101, 103, 104, 107, or 109 of the Act or any rule, regulation, or order issued thereunder, or any term, condition or limitation of any licensee 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.

[38 FR 22217, Aug. 17, 1973, as amended at 40 FR 8783, Mar. 3, 1975]

§ 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.

[40 FR 8783, Mar. 3, 1975]

PART 20—STANDARDS FOR PROTECTION AGAINST RADIATION

General Provisions

Permissible Doses, Levels and Concentrations

Precautionary Procedures

Waste Disposal

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); secs. 201, as amended, 202, 206, Pub. L. 93-438, 88 Stat. 1242, 1244, 1246, Pub. L. 94-79, 89 Stat. 413 (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), 20.205, 20.207, 20.301, 20.303, 20.304 and 20.305 are issued under sec. 161b, 68 Stat. 948, as amended, (42 U.S.C. 2201(b)); and §§ 20.102, 20.103(e), 20.401-20.407, 20.408(b) and 20.409 are issued under sec. 161o, 68 Stat. 950, as amended, (42 U.S.C. 2201(o)).

SOURCE: 25 FR 10914, Nov. 17, 1960, unless otherwise noted.

EDITORIAL NOTE: For nomenclature changes to this part, see 40 FR 8783, Mar. 3, 1975; 45 FR 14200, Mar. 5, 1980.

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.

[25 FR 10914, Nov. 17, 1960, as amended at 40 FR 8783, Mar. 3, 1975; 40 FR 58847, Dec. 19, 1975; 44 FR 32252, June 6, 1979]

§ 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 Part 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.

[46 FR 58282, Dec. 1, 1981, as amended at 47 FR 57479, Dec. 27, 1982]

§ 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.

(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 35, 40, 60, 61, 70, or Part 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 sub-

ject 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. 565 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 measurement of radioactivity defined in § 20.5.

[25 FR 10914, Nov. 17, 1960, as amended at 25 FR 13953, Dec. 30, 1960; 27 FR 5905, June 22, 1962; 38 FR 22487, Aug. 21, 1973; 40 FR 8783, Mar. 3, 1975; 40 FR 42558, Sept. 15, 1975; 44 FR 32352, June 6, 1979; 45 FR 14200, Mar. 5, 1980; 46 FR 58282, Dec. 1, 1981; 47 FR 57479, Dec. 27, 1982]

§ 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 equivalent to a dose of 1 rem (neutrons/cm²)	Average flux to deliver 100 millirem in 40 hours (neutrons/cm² sec.)
Thermal	970×10^6	670
0.0001	720×10^6	500
0.005	820×10^6	570
0.02	400×10^6	280
0.1	120×10^6	80
0.5	43×10^6	30
1.0	26×10^6	18
2.5	29×10^6	20
5.0	26×10^6	18
7.5	24×10^6	17
10	24×10^6	17
10 to 30	14×10^6	10

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

[25 FR 10914, Nov. 17, 1960, as amended at 38 FR 29314, Oct. 24, 1973; 39 FR 23990, June 28, 1974; 40 FR 50705, Oct. 31, 1975]

§ 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.

[40 FR 8783, Mar. 3, 1975]

§ 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 §§ 20.102, 20.103, 20.105, 20.106, 20.203, 20.205, 20.302, 20.311, 20.401, 20.402, 20.403, 20.405, 20.407, 20.408, and 20.409.

(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 20.102, Form NRC-4 is approved under control number 3150-0005.

(2) In § 20.401, Form NRC-5 is approved under control number 3150-0006.

[49 FR 19626, May 9, 1984]

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.

[25 FR 10914, Nov. 17, 1960, as amended at 44 FR 32352, June 6, 1979]

§ 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 for calendar quarters prior to Jan. 1, 1961	Column 2—Assumed exposure in rems for calendar quarters beginning on or after Jan. 1, 1961
Whole body, gonads, active blood-forming organs, head and trunk, lens of eye	3¾	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.

[25 FR 10914, Nov. 17, 1960, as amended at 41 FR 18301, May 3, 1976; 44 FR 32352, June 6, 1979]

§ 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.[1,2,3] 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[4,5] in any calen-

[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 S 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 § 20.105(b)(1).

[3] Multiply the concentration values specified in Appendix B, Table I, Column 1, by 6.3×10^{4} ml to obtain the quarterly quantity limit. Multiply the concentration value specified in Appendix B, Table I, Column 1, by 2.5×10^{6} 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

Continued

dar 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 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, it takes less than those which would result from inhalation for 2 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)(i).

(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)(i), 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 had certification extended by the National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA). The licensee may make allowance for this use of respiratory protective equipment in estimating exposures of individuals to this material provided that:

(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 purposes 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 had certification extended, by NIOSH/MSHA, or where there is no existing schedule for test and certification of certain equipment, the licensee shall not make allowance 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 In-

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.

[1] 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.

spection 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.

[41 FR 52301, Nov. 29, 1976, as amended at 43 FR 25270, July 7, 1978; 47 FR 16164, Apr. 15, 1982]

§ 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.

[25 FR 10914, Nov. 17, 1960, as amended at 41 FR 52302, Nov. 29, 1976]

§ 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.

[25 FR 10914, Nov. 17, 1960, and 46 FR 18538, Mar. 25, 1981]

§ 20.106 Radioactivity in effluents to unrestricted areas.

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

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

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

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

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

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

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

(i) Chemical composition;

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

(iii) The hydrogen ion concentrations (p^H) of liquid effluents; and

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

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

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

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

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

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

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

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

(d) For the purposes of this section the concentration limits in Appendix B, Table II of this part shall apply at the boundary of the restricted area. The concentration of radioactive material discharged through a stack, pipe or similar conduit may be determined with respect to the point where the material leaves the conduit. If the conduit discharges within the restricted area, the concentration at the boundary may be determined by applying appropriate factors for dilution, dispersion, or decay between the point of discharge and the boundary.

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

(f) The provisions of 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.

(Secs. 161b., 161o., Pub. L. 83-703, 68 Stat. 948, 950 (42 U.S.C. 2201); sec. 201, as amended, Pub. L. 93-438, 88 Stat. 1243, Pub. L. 94-79, 89 Stat. 413, (42 U.S.C. 5841); Memorandum of Understanding between the Environmental Protection Agency and the

Atomic Energy Commission, August 1973, 38 FR 24938, September 11, 1973]

[29 FR 14434, Oct. 21, 1964, as amended at 46 FR 18526, Mar. 25, 1981]

§ 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.

(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.

[[35 FR 10914, Nov. 17, 1960, as amended at 46 FR 53868, Oct. 30, 1981]

§ 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.

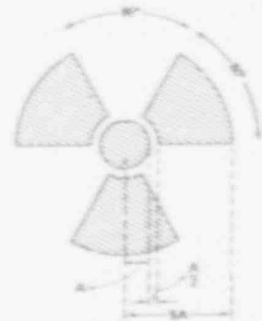
(3) "High radiation area" means any area, accessible to personnel, in which there exists radiation originating in whole or in part within licensed material at such levels that a major portion of the body could receive in any one hour a dose in excess of 100 millirem.

§ 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

(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)(2) of this section is met.

(6) Each area in which there may exist radiation levels in excess of 500 rems in one hour at one meter from a sealed radio-active source [2] that is used to irradiate materials shall: [3]

[1] Or "Danger".

[2] 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 not to manufacture reactor generated radiation other than radiation from byproduct, source, or special nuclear materials that are used to make sources in non-self shielded irradiators.

[3] 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, [illegible]

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

(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 uninterrupted; 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 or 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 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

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formation 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)(4) until such compliance is achieved. For such persons compliance must be achieved not later than Dec. 14, 1978.

[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.

permit individuals handling or using the containers, or working in the vicinity thereof, to take precautions to avoid or minimize exposures.

(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 II 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[*] 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.

(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.

[25 FR 10914, Nov. 17, 1960, as amended at 31 FR 10515, Aug. 5, 1966; 34 FR 19546, Dec. 11, 1969; 35 FR 5033, Mar. 25, 1970; 42 FR 54620, Dec. 27, 1977; 43 FR 2177, Jan. 16, 1978; 43 FR 22172, May 24, 1978]

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

§ 20.206 Same: Exceptions.

Notwithstanding the provisions of § 20.203,

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

(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.

[25 FR 10914, Nov. 17, 1960, as amended at 35 FR 5033, Mar. 25, 1970]

§ 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 Regional Office shown in Appendix D of this part.

TABLE OF EXEMPT AND TYPE A QUANTITIES

Transport group[1]	Exempt quantity level (in millicuries)	Type A quantity level (in curies)
I	.01	0.001
II	0.1	0.050
III	1	3
IV	1	20
V	1	20
VI	1	1000
VII	10,000	1000
Special Form	1	20

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

(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.

[39 FR 17974, May 22, 1974, as amended at 41 FR 16445, Apr. 19, 1976; 49 FR 19624, May 9, 1984]

§ 20.206 Instruction of personnel.

Instructions required for individuals working in or frequenting any portion

of a restricted area are specified in § 19.13 of this chapter.

[38 FR 22220, Aug. 17, 1973]

§ 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.

[40 FR 28678, June 25, 1975]

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 pursuant to § 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).

[25 FR 10914, Nov. 17, 1960, as amended at 46 FR 16234, Mar. 11, 1981; 46 FR 36282, Dec. 1, 1981; 47 FR 57479, Dec. 27, 1982]

§ 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.

[25 FR 10914, Nov. 17, 1960, as amended at 26 FR 852, Jan. 18, 1961; 36 FR 23138, Dec. 4, 1971; 47 FR 57479, Dec. 27, 1982]

§ 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 2 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 2 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.

[25 FR 10914, Nov. 17, 1960, as amended at 46 FR 16234, Mar. 11, 1981]

§ 20.305 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.

[46 FR 16234, Mar. 11, 1981]

§ 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 and local regulations governing any other toxic or hazardous property of these materials.

[46 FR 16234, Mar. 11, 1981]

§ 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, volume, radionuclide identity, quantity, the total radioactivity, the principal chemical form. [illegible] 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 gener-

ating 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 30, 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 30, 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 30, 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.

[47 FR 57478, Dec. 27, 1982]

Records, Reports, and Notification

§ 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 § 20.201(b), monitoring required by §§ 20.205(b) and 20.206(c), and disposals made under §§ 20.302, 20.303, removed § 20.304,[1] 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 § 20.108, shall be preserved until the Commission authorizes disposition.

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

[1] Section 20.304 provided for burial of small quantities of licensed materials in soil. Notice of its removal appears in the FEDERAL REGISTER of October 30, 1980 (45 FR 71782).

sults of surveys used to evaluate the release of radioactive effluents to the environment.

(3) Records of disposal of licensed materials made pursuant to §§ 20.302, 20.303, 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.

[25 FR 10914, Nov. 17, 1960, as amended at 41 FR 18301, May 3, 1976; 47 FR 57480, Dec. 27, 1982]

§ 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:

(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.

(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.

[24 FR 7506, May 9, 1969, as amended at 39 FR 1271, Jan. 11, 1973; 48 FR 33859, July 26, 1983]

§ 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 or 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

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

(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

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

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

(d) 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.

[27 FR 5905, June 22, 1962, as amended at 28 FR 6823, July 3, 1963; 42 FR 53986, Sept. 1, 1977; 43 FR 2719, Jan. 19, 1978; 48 FR 33859, July 26, 1983]

§ 20.404 [Reserved]

§ 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;

(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 § 20.403 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) Estimate 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 § 20.403 of this part, each licensee shall make a report in writing of levels of radiation or releases 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 § 50.73 (b), (c), (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.

[35 FR 10914, Nov. 17, 1950, as amended at 35 FR 15568, Sept. 29, 1970; 46 FR 18526, Mar. 25, 1981; 48 FR 32860, July 25, 1983]

§ 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.

[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.

(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:

Estimated whole body exposure range (rems)[1]	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+	

[1] Individual 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 recorded. This section does not require improved measurements.

[43 FR 44829, Sept. 29, 1978, as amended at 49 FR 24513, June 14, 1984]

§ 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 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 5,000 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:

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

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

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

(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 incurred during the period of employment or work assignment in the licensee's facility, containing information recorded by the licensee pursuant to §§ 20.401(a) and 20.108. Such report shall be furnished within 30 days after the exposure of the individual has been determined by the licensee or 90 days after the date of termination of

employment or work assignment, whichever is earlier.

[43 FR 44829, Sept. 29, 1978, as amended at 46 FR 13978, Feb. 25, 1981; 46 FR 58082, Dec. 1, 1981; 47 FR 57480, Dec. 27, 1982; 49 FR 24513, June 14, 1984; 50 FR 24065, Aug. 23, 1985]

§ 20.409 Notifications and reports to individuals.

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

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

[39 FR 23220, Aug. 17, 1973]

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.

[40 FR 8784, Mar. 3, 1975]

Appendix A—Protection Factors for Respirators *

Description *	Modes *	Protection factors *		Tested and certified equipment—National Institute for Occupational Safety and Health/Mine Safety and Health Administration tests for permeability
		Particulates only	Particulates, gases and vapors *	
1. Air-purifying respirators: *				
Facepiece, half-mask *	NP	10		30 CFR Part 11, Subpart K.
Facepiece, full	NP	50		
Facepiece, half-mask, full, or hood	PP	1,000		
II. Atmosphere-supplying respirators:				
1. Air-line respirator:				
Facepiece, half-mask	CF		1,000	
Facepiece, half-mask	D		5	
Facepiece, full	CF		2,000	
Facepiece, full	D		5	30 CFR Part 11, Subpart J.
Facepiece, full	PD		2,000	
Hood	CF		(*)	
Suit	CF		(*)	(*)

Appendix A—Protection Factors for Respirators *—Continued

Description *	Modes *	Protection factors *		Tested and certified equipment—National Institute for Occupational Safety and Health/Mine Safety and Health Administration tests for permeability
		Particulates only	Particulates, gases and vapors *	
2. Self-contained breathing apparatus (SCBA):				
Facepiece, full	D		50	
Facepiece, full	PD		* 10,000	30 CFR Part 11, Subpart H.
Facepiece, full	RD		50	
Facepiece, full	RP		* 5,000	
III. Combination respirator. Any combination of air-purifying and atmosphere-supplying respirators.			*	30 CFR Part 11, § 11.83(b).

* For use in the selection of respiratory protective devices to be used only where the contaminants have been identified and the concentrations (or possible concentrations) are known.

* Only for shaven faces and where nothing interferes with the seal of tight-fitting facepieces against the skin. (Hoods and suits are excepted.)

* The mode symbols are defined as follows: CF = continuous flow, D = demand, NP = negative pressure (i.e., negative phase during inhalation), PD = pressure demand (i.e., air-line positive pressure), PP = positive pressure, RD = demand, recirculating (closed circuit), RP = positive pressure recirculating (closed circuit).

* The protection factor (4.a. modified) of this degree of protection afforded by a respirator, defined as the ratio of the concentration of airborne radioactive material outside the respirator (protective equipment) to that inside the equipment (usually inside the facepiece) under conditions of use. It is applied to the ambient airborne concentration to estimate the concentration inhaled by the wearer according to the following formula:

Concentration inhaled = (Ambient airborne concentration)/(Protection factor).

* The protection factors apply:

(a) Only for trained individuals wearing properly fitted respirators used and maintained under supervision in a well-planned respiratory protective program.

(b) For air-purifying respirators only when high efficiency particulate filters (above 99.97% removal efficiency by thermally generated 0.3 μm dioctyl phthalate (DOP) test) are used in atmospheres not deficient in oxygen and not containing radioactive gas or vapor respiratory hazards.

(c) No allowance is to be made for the use of sorbents against radioactive gases or vapors.

(d) For atmosphere-supplying respirators only when supplied with adequate respirable air. Respirable air shall be provided of the quality and quantity required in accordance with NIOSH/MSHA certification (described in 30 CFR Part 11). Oxygen and air shall not be used in the same apparatus.

* Excluding radioactive contaminants that present an absorption or submersion hazard. For tritium oxide, approximately one half of the intake results by absorption through the skin so that an overall protection factor of less than 2 is appropriate when atmosphere-supplying respirators are used to protect against tritium oxide. If the protection factor for a device is 5, the effective protection factor for tritium is about 1.7; for devices with protection factors of 10 the effective factor for tritium oxide is about 1.7; and for devices with protection factors of 100 or more the effective factor for tritium oxide is about 1.9. Air-purifying respirators are not suitable for protection against tritium oxide. See also fournote 1 concerning supplied-air suits.

* Canisters and cartridges shall not be used beyond service-life limitations.

* Under-chin type only. This type of respirator is not satisfactory for use where it might be possible (e.g., in an accident or emergency work to occur) for the ambient airborne concentration to reach instantaneous values greater than 10 times the pertinent values in Table I, Column 1 of Appendix B of this part. This type of respirator is not suitable for protection against plutonium or other high-toxicity materials. The mask shall be tested for fit with irritant smoke, prior to use, each time it is donned.

* Equipment shall be operated in a manner that ensures that proper air flow-rates are maintained. A protection factor of no more than 1000 may be used for tested-and-certified supplied-air hoods when a minimum air flow of 6 cubic feet per minute is maintained and calibrated airline pressure gauges or flow measuring devices are used. A protection factor of up to 2000 may be used for tested and certified hoods only when the air flow is maintained at the manufacturer's recommended maximum rate or the equipment, this rate is greater than 6 cubic feet per minute, and calibrated airline pressure gauges or flow measuring devices are used.

The design of the supplied-air hood or helmet (with a minimum flow of 6 cfm of air) may determine its overall efficiency and the protection it provides. For example, some hoods aspirate contaminated air into the breathing zone when the wearer works with hands over head. This aspiration may be overcome if a short cape-like extension to the hood is worn under a coat or overalls. Other limitations specified by the approval agency shall be considered before using a hood in certain types of atmospheres, such as the design and its permeability to the contaminant under conditions of use.

Appropriate protection factors shall be determined (see 20.103(a)), taking into account the design of the suit and its permeability to the contaminant under conditions of use. There shall be a standby rescue person equipped with self-contained breathing apparatus and communications equipment whenever supplied-air suits are used.

* No approval schedules are currently available for this equipment. Equipment shall be evaluated by testing or on the basis of relative test information.

* This type of respirator may provide greater protection and be used as an emergency device or unknown concentrations for protection against inhalation hazards. External radiation hazards and other limitations to permitted exposure such as skin absorption shall be taken into account in these circumstances.

Quantitative fit testing shall be performed on each individual and no more than 0.02% leakage is allowed with this type of apparatus. Perceptible outward leakage of gas from the or any positive pressure self-contained breathing apparatus is unacceptable because service life will be reduced substantially. Special training in the use of this type of apparatus shall be provided to the wearer (see footnote k).

* Protection factor for type and mode of operation as listed above.

Note 1: Protection factors for respirators, as may be approved by the U.S. Bureau of Mines/National Institute for Occupational Safety and Health (NIOSH) according to applicable approvals for respirators for type and mode of use to protect against airborne radionuclides, may be used to the extent that they do not exceed the protection factors listed in this table. The protection factors listed in this table may not be appropriate to circumstances where chemical or other respiratory 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 1, 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.

[47 FR 16186, Apr. 15, 1982; 47 FR 19011, May 6, 1982]

Appendix B—Concentrations in Air and Water Above Natural Background

[See footnotes at end of Appendix B]

Element (atomic number)	Isotope		Table 1		Table 2	
			Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)	Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)
Actinium (89)	Ac 227	S	9×10^{-12}	6×10^{-4}	3×10^{-13}	2×10^{-5}
		I	2×10^{-11}	9×10^{-4}	6×10^{-13}	3×10^{-5}
	Ac 228	S	8×10^{-9}	3×10^{-7}	3×10^{-10}	9×10^{-9}
		I	2×10^{-8}	3×10^{-7}	6×10^{-10}	9×10^{-9}
Americium (95)	Am 241	S	8×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-11}	5×10^{-4}	4×10^{-13}	2×10^{-5}
	Am 242m	S	8×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	2×10^{-11}	5×10^{-4}	6×10^{-13}	2×10^{-5}
	Am 242	S	4×10^{-11}	4×10^{-4}	1×10^{-12}	1×10^{-5}
		I	5×10^{-11}	4×10^{-4}	2×10^{-12}	1×10^{-5}
	Am 243	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-11}	6×10^{-4}	4×10^{-13}	2×10^{-5}
	Am 244	S	4×10^{-9}	1×10^{-7}	1×10^{-10}	5×10^{-9}
		I	2×10^{-8}	1×10^{-7}	6×10^{-10}	5×10^{-9}
Antimony	Sb 122	S	2×10^{-9}	5×10^{-8}	8×10^{-11}	2×10^{-6}
		I	1×10^{-8}	6×10^{-8}	5×10^{-10}	3×10^{-6}
	Sb 124	S	2×10^{-9}	7×10^{-8}	6×10^{-11}	2×10^{-6}
		I	2×10^{-9}	7×10^{-8}	7×10^{-10}	2×10^{-6}
	Sb 125	S	5×10^{-10}	3×10^{-8}	2×10^{-11}	1×10^{-6}
		I	3×10^{-9}	3×10^{-8}	9×10^{-11}	1×10^{-6}
Argon (18)	A 37	Sub*	8×10^{-5}		1×10^{-6}	
	A 41	Sub	2×10^{-8}		4×10^{-7}	
Arsenic (33)	As 73	S	2×10^{-9}	1×10^{-7}	7×10^{-11}	5×10^{-6}
		I	4×10^{-9}	1×10^{-7}	1×10^{-10}	5×10^{-6}
	As 74	S	5×10^{-9}	2×10^{-7}	1×10^{-10}	5×10^{-6}
		I	1×10^{-8}	2×10^{-7}	4×10^{-10}	5×10^{-6}
	As 76	S	1×10^{-9}	6×10^{-8}	4×10^{-11}	2×10^{-6}
		I	1×10^{-9}	8×10^{-8}	3×10^{-10}	2×10^{-6}
	As 77	S	8×10^{-10}	2×10^{-7}	2×10^{-11}	8×10^{-6}
		I	4×10^{-9}	2×10^{-7}	1×10^{-10}	8×10^{-6}
Astatine (85)	At 211	S	7×10^{-9}	5×10^{-7}	2×10^{-10}	2×10^{-5}
		I	9×10^{-9}	2×10^{-7}	1×10^{-10}	7×10^{-6}
Barium (56)	Ba 131	S	1×10^{-9}	5×10^{-8}	4×10^{-11}	2×10^{-6}
		I	4×10^{-9}	5×10^{-8}	1×10^{-10}	2×10^{-6}
	Ba 140	S	1×10^{-9}	8×10^{-8}	4×10^{-11}	3×10^{-6}
		I	4×10^{-9}	7×10^{-8}	1×10^{-10}	2×10^{-6}
Berkelium (97)	Bk 249	S	2×10^{-10}	2×10^{-6}	2×10^{-11}	6×10^{-5}
		I	1×10^{-9}	2×10^{-6}	4×10^{-11}	6×10^{-5}
	Bk 250	S	1×10^{-9}	6×10^{-8}	5×10^{-11}	2×10^{-6}
		I	6×10^{-9}	6×10^{-8}	4×10^{-10}	2×10^{-6}
Beryllium (4)	Be 7	S	1×10^{-8}	5×10^{-8}	2×10^{-10}	2×10^{-6}
		I	6×10^{-8}	5×10^{-8}	4×10^{-10}	2×10^{-6}
Bismuth (83)	Bi 206	S	2×10^{-9}	1×10^{-7}	6×10^{-11}	4×10^{-6}
		I	1×10^{-8}	1×10^{-7}	5×10^{-10}	4×10^{-6}
	Bi 207	S	2×10^{-9}	2×10^{-7}	8×10^{-11}	8×10^{-6}
		I	1×10^{-8}	2×10^{-7}	8×10^{-10}	8×10^{-6}
	Bi 210	S	6×10^{-10}	1×10^{-7}	2×10^{-11}	4×10^{-6}
		I	6×10^{-9}	1×10^{-7}	2×10^{-10}	4×10^{-6}
	Bi 212	S	1×10^{-9}	1×10^{-7}	3×10^{-11}	4×10^{-6}
		I	2×10^{-9}	1×10^{-7}	7×10^{-11}	4×10^{-6}
Bromine (35)	Br 82	S	1×10^{-9}	4×10^{-8}	4×10^{-11}	3×10^{-6}
		I	2×10^{-9}	4×10^{-8}	8×10^{-11}	4×10^{-6}
Cadmium (48)	Cd 109	S	5×10^{-10}	5×10^{-8}	2×10^{-11}	2×10^{-6}
		I	7×10^{-10}	5×10^{-8}	3×10^{-11}	2×10^{-6}
	Cd 115m	S	4×10^{-9}	7×10^{-8}	1×10^{-10}	3×10^{-6}
		I	4×10^{-9}	7×10^{-8}	1×10^{-10}	3×10^{-6}
	Cd 115	S	2×10^{-9}	1×10^{-7}	9×10^{-11}	3×10^{-6}

Appendix B—Concentrations in Air and Water Above Natural Background—Continued

[See footnotes at end of Appendix B]

Element (atomic number)	Isotope		Table 1		Table 2	
			Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)	Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)
Calcium (20)	Ca 45	S	2×10^{-9}	1×10^{-7}	8×10^{-11}	4×10^{-6}
		I	2×10^{-9}	3×10^{-7}	1×10^{-10}	4×10^{-6}
	Ca 47	S	1×10^{-9}	5×10^{-8}	4×10^{-11}	2×10^{-6}
		I	2×10^{-9}	1×10^{-7}	8×10^{-11}	3×10^{-6}
Californium (98)	Cf 249	S	2×10^{-12}	1×10^{-4}	5×10^{-14}	4×10^{-6}
		I	1×10^{-11}	1×10^{-4}	5×10^{-14}	2×10^{-6}
	Cf 250	S	5×10^{-12}	4×10^{-4}	2×10^{-13}	1×10^{-5}
		I	1×10^{-11}	4×10^{-4}	2×10^{-13}	2×10^{-5}
	Cf 251	S	2×10^{-12}	1×10^{-4}	8×10^{-14}	3×10^{-6}
		I	1×10^{-11}	8×10^{-4}	3×10^{-13}	3×10^{-5}
	Cf 252	S	8×10^{-12}	2×10^{-4}	2×10^{-13}	7×10^{-6}
		I	2×10^{-11}	2×10^{-4}	7×10^{-13}	7×10^{-6}
	Cf 253	S	5×10^{-11}	4×10^{-4}	2×10^{-12}	1×10^{-5}
		I	5×10^{-11}	4×10^{-4}	2×10^{-12}	1×10^{-5}
	Cf 254	S	3×10^{-12}	4×10^{-4}	2×10^{-13}	1×10^{-5}
		I	4×10^{-12}	4×10^{-4}	1×10^{-13}	1×10^{-5}
Carbon (6)	C 14 (CO2)	S	5×10^{-7}		1×10^{-8}	
		Sub	4×10^{-7}	3×10^{-5}	2×10^{-8}	1×10^{-6}
Cerium (58)	Ce 141	S	2×10^{-9}	3×10^{-7}	5×10^{-11}	8×10^{-6}
		I	2×10^{-9}	3×10^{-7}	6×10^{-11}	8×10^{-6}
	Ce 143	S	1×10^{-9}	1×10^{-7}	4×10^{-11}	4×10^{-6}
		I	1×10^{-9}	1×10^{-7}	4×10^{-11}	4×10^{-6}
	Ce 144	S	6×10^{-11}	3×10^{-7}	2×10^{-12}	1×10^{-5}
		I	7×10^{-11}	3×10^{-7}	2×10^{-12}	1×10^{-5}
Cesium (55)	Cs 131	S	3×10^{-9}	2×10^{-7}	1×10^{-10}	6×10^{-6}
		I	4×10^{-9}	2×10^{-7}	1×10^{-10}	6×10^{-6}
	Cs 134m	S	6×10^{-9}	3×10^{-6}	2×10^{-10}	1×10^{-4}
		I	9×10^{-9}	3×10^{-6}	3×10^{-10}	1×10^{-4}
	Cs 134	S	4×10^{-10}	1×10^{-7}	1×10^{-11}	4×10^{-6}
		I	5×10^{-10}	1×10^{-7}	2×10^{-11}	4×10^{-6}
	Cs 135	S	6×10^{-10}	7×10^{-8}	2×10^{-11}	2×10^{-6}
		I	6×10^{-9}	7×10^{-8}	2×10^{-10}	2×10^{-6}
	Cs 136	S	6×10^{-10}	4×10^{-8}	2×10^{-11}	1×10^{-6}
		I	2×10^{-9}	4×10^{-8}	6×10^{-11}	1×10^{-6}
	Cs 137	S	1×10^{-9}	1×10^{-7}	4×10^{-11}	2×10^{-6}
		I	1×10^{-9}	1×10^{-7}	4×10^{-11}	2×10^{-6}
Chlorine (17)	Cl 36	S	3×10^{-9}	2×10^{-7}	1×10^{-10}	6×10^{-6}
		I	4×10^{-9}	2×10^{-7}	1×10^{-10}	6×10^{-6}
	Cl 38	S	2×10^{-9}	1×10^{-7}	8×10^{-11}	4×10^{-6}
		I	2×10^{-9}	1×10^{-7}	7×10^{-11}	4×10^{-6}
Chromium (24)	Cr 51	S	2×10^{-8}	1×10^{-6}	7×10^{-10}	4×10^{-5}
		I	2×10^{-8}	1×10^{-6}	7×10^{-10}	4×10^{-5}
Cobalt (27)	Co 57	S	3×10^{-9}	2×10^{-7}	1×10^{-10}	8×10^{-6}
		I	2×10^{-9}	2×10^{-7}	8×10^{-11}	8×10^{-6}
	Co 58m	S	2×10^{-8}	8×10^{-7}	6×10^{-10}	3×10^{-5}
		I	2×10^{-8}	8×10^{-7}	6×10^{-10}	3×10^{-5}
	Co 58	S	6×10^{-9}	4×10^{-7}	2×10^{-10}	1×10^{-5}
		I	6×10^{-9}	4×10^{-7}	2×10^{-10}	1×10^{-5}
	Co 60	S	2×10^{-10}	1×10^{-7}	6×10^{-12}	4×10^{-6}
		I	2×10^{-9}	1×10^{-7}	6×10^{-11}	4×10^{-6}
Copper (29)	Cu 64	S	3×10^{-9}	1×10^{-7}	9×10^{-11}	5×10^{-6}
		I	3×10^{-9}	1×10^{-7}	9×10^{-11}	5×10^{-6}
Curium (96)	Cm 242	S	1×10^{-11}	7×10^{-4}	4×10^{-13}	2×10^{-5}
		I	2×10^{-11}	7×10^{-4}	6×10^{-13}	2×10^{-5}
	Cm 243	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	3×10^{-6}
		I	1×10^{-11}	1×10^{-4}	6×10^{-14}	3×10^{-6}
	Cm 244	S	2×10^{-12}	1×10^{-4}	7×10^{-14}	3×10^{-6}
		I	1×10^{-11}	1×10^{-4}	7×10^{-14}	3×10^{-6}
	Cm 245	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	3×10^{-6}
		I	1×10^{-11}	1×10^{-4}	6×10^{-14}	3×10^{-6}
	Cm 246	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	3×10^{-6}
		I	1×10^{-11}	1×10^{-4}	6×10^{-14}	3×10^{-6}
	Cm 247	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	3×10^{-6}

APPENDIX B—CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—Continued

(See footnotes at end of Appendix B)

Element (atomic number)	Isotope [1]		Table I		Table II	
			Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)	Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)
	Cm 248	S	6×10^{-14}	1×10^{-6}	2×10^{-14}	4×10^{-7}
		I	1×10^{-13}	4×10^{-6}	4×10^{-14}	1×10^{-6}
	Cm 249	S	1×10^{-4}	6×10^{-3}	4×10^{-7}	2×10^{-4}
		I	1×10^{-4}	6×10^{-3}	4×10^{-7}	2×10^{-4}
Dysprosium (66)	Dy 155	S	1×10^{-5}	1×10^{-7}	2×10^{-7}	4×10^{-9}
		I	2×10^{-5}	1×10^{-7}	7×10^{-7}	4×10^{-9}
	Dy 159	S	2×10^{-4}	1×10^{-6}	8×10^{-9}	4×10^{-8}
		I	2×10^{-4}	1×10^{-6}	7×10^{-9}	4×10^{-8}
Einsteinium (99)	Es 253	S	9×10^{-14}	7×10^{-6}	3×10^{-14}	2×10^{-7}
		I	6×10^{-13}	7×10^{-6}	2×10^{-13}	2×10^{-7}
	Es 254m	S	8×10^{-5}	5×10^{-7}	2×10^{-8}	2×10^{-8}
		I	8×10^{-5}	5×10^{-7}	2×10^{-8}	2×10^{-8}
	Es 254	S	2×10^{-13}	4×10^{-6}	6×10^{-14}	1×10^{-7}
		I	1×10^{-13}	4×10^{-6}	4×10^{-14}	1×10^{-7}
	Es 255	S	5×10^{-14}	8×10^{-7}	2×10^{-14}	3×10^{-8}
		I	4×10^{-14}	8×10^{-7}	1×10^{-14}	3×10^{-8}
Erbium (68)	Er 169	S	4×10^{-4}	2×10^{-6}	2×10^{-8}	8×10^{-8}
		I	4×10^{-4}	2×10^{-6}	1×10^{-8}	8×10^{-8}
	Er 171	S	7×10^{-5}	3×10^{-7}	2×10^{-8}	1×10^{-8}
		I	6×10^{-5}	3×10^{-7}	2×10^{-8}	1×10^{-8}
Europium (63)	Eu 150	S	4×10^{-5}	2×10^{-7}	1×10^{-8}	7×10^{-9}
	(T1/2=9.2 hrs)	I	3×10^{-5}	2×10^{-7}	1×10^{-8}	6×10^{-9}
	Eu 152	S	1×10^{-5}	2×10^{-7}	4×10^{-9}	6×10^{-9}
	(T1/2=13 yrs)	I	2×10^{-5}	2×10^{-7}	6×10^{-9}	8×10^{-9}
	Eu 154	S	4×10^{-5}	8×10^{-7}	1×10^{-8}	2×10^{-8}
		I	7×10^{-5}	8×10^{-7}	2×10^{-8}	2×10^{-8}
	Eu 155	S	8×10^{-5}	8×10^{-7}	3×10^{-8}	2×10^{-8}
		I	7×10^{-5}	8×10^{-7}	3×10^{-8}	2×10^{-8}
Fermium (100)	Fm 254	S	8×10^{-4}	4×10^{-6}	3×10^{-7}	1×10^{-7}
		I	7×10^{-4}	4×10^{-6}	2×10^{-7}	1×10^{-7}
	Fm 255	S	2×10^{-5}	1×10^{-7}	9×10^{-9}	3×10^{-8}
		I	1×10^{-5}	1×10^{-7}	4×10^{-9}	3×10^{-8}
	Fm 256	S	3×10^{-6}	3×10^{-8}	1×10^{-9}	9×10^{-9}
		I	3×10^{-6}	3×10^{-8}	8×10^{-10}	9×10^{-9}
Fluorine (9)	F 18	S	5×10^{-5}	2×10^{-7}	2×10^{-8}	8×10^{-8}
		I	3×10^{-5}	1×10^{-7}	9×10^{-9}	5×10^{-8}
Gadolinium (64)	Gd 153	S	8×10^{-5}	6×10^{-7}	3×10^{-8}	2×10^{-8}
		I	4×10^{-4}	6×10^{-6}	3×10^{-7}	2×10^{-7}
	Gd 159	S	5×10^{-5}	2×10^{-7}	2×10^{-8}	8×10^{-8}
		I	4×10^{-5}	2×10^{-7}	1×10^{-8}	8×10^{-8}
Gallium (31)	Ga 72	S	2×10^{-5}	1×10^{-7}	8×10^{-9}	4×10^{-8}
		I	2×10^{-5}	1×10^{-7}	6×10^{-9}	4×10^{-8}
Germanium (32)	Ge 71	S	1×10^{-4}	6×10^{-6}	5×10^{-7}	2×10^{-7}
		I	8×10^{-5}	6×10^{-6}	2×10^{-7}	2×10^{-7}
Gold (79)	Au 195	S	1×10^{-4}	8×10^{-6}	4×10^{-8}	2×10^{-7}
		I	6×10^{-5}	4×10^{-6}	2×10^{-8}	1×10^{-7}
	Au 198	S	3×10^{-5}	2×10^{-7}	1×10^{-8}	5×10^{-8}
		I	2×10^{-5}	1×10^{-7}	8×10^{-9}	5×10^{-8}
	Au 199	S	1×10^{-4}	8×10^{-6}	4×10^{-8}	2×10^{-7}
		I	8×10^{-5}	6×10^{-6}	3×10^{-8}	2×10^{-7}
Hafnium (72)	Hf 181	S	4×10^{-5}	3×10^{-7}	1×10^{-8}	7×10^{-8}
		I	3×10^{-5}	2×10^{-7}	1×10^{-8}	7×10^{-8}
Holmium (67)	Ho 166	S	2×10^{-5}	9×10^{-7}	7×10^{-9}	3×10^{-8}
		I	2×10^{-5}	9×10^{-7}	6×10^{-9}	3×10^{-8}
Hydrogen (1)	H3	S	5×10^{-4}	1×10^{-3}	2×10^{-7}	3×10^{-7}
		I	6×10^{-4}	1×10^{-3}	2×10^{-7}	3×10^{-7}
		Sub	2×10^{-4}		4×10^{-8}	
Indium (49)	In 113m	S	4×10^{-4}	4×10^{-6}	3×10^{-7}	1×10^{-7}
		I	7×10^{-4}	4×10^{-6}	2×10^{-7}	1×10^{-7}
	In 114m	S	1×10^{-5}	8×10^{-8}	4×10^{-9}	2×10^{-8}
		I	2×10^{-5}	5×10^{-7}	7×10^{-9}	2×10^{-8}
	In 115m	S	2×10^{-4}	1×10^{-6}	8×10^{-8}	4×10^{-7}
		I	2×10^{-4}	1×10^{-6}	8×10^{-8}	4×10^{-7}
	In 115	S	2×10^{-5}	9×10^{-7}	6×10^{-9}	3×10^{-8}
		I	8×10^{-5}	2×10^{-6}	1×10^{-8}	8×10^{-8}

APPENDIX B—CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—Continued

(See footnotes at end of Appendix B)

Element (atomic number)	Isotope [1]		Table I		Table II	
			Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)	Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)
Iodine (53)	I 125	S	5×10^{-8}	4×10^{-6}	8×10^{-9}	2×10^{-7}
		I	2×10^{-7}	4×10^{-6}	8×10^{-9}	2×10^{-7}
	I 126	S	5×10^{-8}	3×10^{-6}	8×10^{-9}	3×10^{-7}
		I	3×10^{-7}	3×10^{-6}	1×10^{-8}	9×10^{-8}
	I 129	S	2×10^{-8}	1×10^{-6}	2×10^{-9}	8×10^{-8}
		I	7×10^{-8}	8×10^{-6}	2×10^{-9}	2×10^{-7}
	I 131	S	9×10^{-9}	6×10^{-7}	1×10^{-9}	3×10^{-8}
		I	3×10^{-8}	2×10^{-6}	1×10^{-9}	8×10^{-8}
	I 132	S	2×10^{-7}	2×10^{-6}	3×10^{-9}	8×10^{-8}
		I	9×10^{-8}	5×10^{-6}	3×10^{-9}	2×10^{-7}
	I 133	S	5×10^{-8}	2×10^{-6}	4×10^{-9}	1×10^{-7}
		I	2×10^{-7}	1×10^{-6}	7×10^{-9}	4×10^{-8}
	I 134	S	5×10^{-7}	4×10^{-6}	8×10^{-9}	2×10^{-7}
		I	3×10^{-8}	2×10^{-6}	1×10^{-9}	8×10^{-8}
	I 135	S	1×10^{-8}	7×10^{-7}	1×10^{-9}	4×10^{-8}
		I	4×10^{-8}	2×10^{-6}	1×10^{-9}	7×10^{-8}
Iridium (77)	Ir 190	S	1×10^{-5}	8×10^{-7}	4×10^{-8}	2×10^{-7}
		I	9×10^{-6}	8×10^{-7}	3×10^{-8}	2×10^{-7}
	Ir 192	S	1×10^{-7}	1×10^{-6}	4×10^{-9}	4×10^{-8}
		I	3×10^{-7}	1×10^{-6}	8×10^{-9}	4×10^{-8}
	Ir 194	S	2×10^{-5}	1×10^{-7}	6×10^{-9}	3×10^{-8}
		I	2×10^{-5}	8×10^{-7}	5×10^{-9}	3×10^{-8}
Iron (26)	Fe 55	S	8×10^{-5}	2×10^{-6}	3×10^{-8}	8×10^{-8}
		I	1×10^{-4}	7×10^{-6}	3×10^{-8}	2×10^{-7}
	Fe 59	S	1×10^{-5}	2×10^{-7}	6×10^{-9}	8×10^{-8}
		I	5×10^{-5}	2×10^{-6}	2×10^{-8}	8×10^{-8}
Krypton (36)	Kr 85m	Sub	6×10^{-6}		1×10^{-7}	
	Kr 85	Sub	1×10^{-4}		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	S	2×10^{-5}	7×10^{-7}	3×10^{-8}	2×10^{-8}
		I	1×10^{-5}	7×10^{-7}	4×10^{-9}	2×10^{-8}
Lead (82)	Pb 203	S	3×10^{-5}	1×10^{-7}	9×10^{-9}	4×10^{-8}
		I	2×10^{-5}	1×10^{-7}	8×10^{-9}	4×10^{-8}
	Pb 210	S	1×10^{-9}	4×10^{-9}	4×10^{-10}	1×10^{-9}
		I	2×10^{-9}	2×10^{-8}	6×10^{-10}	3×10^{-9}
	Pb 212	S	2×10^{-6}	8×10^{-8}	6×10^{-10}	2×10^{-8}
		I	2×10^{-6}	5×10^{-8}	7×10^{-10}	2×10^{-8}
Lutetium (71)	Lu 177	S	8×10^{-5}	3×10^{-7}	2×10^{-8}	1×10^{-8}
		I	6×10^{-5}	3×10^{-7}	2×10^{-8}	1×10^{-8}
Manganese (25)	Mn 52	S	2×10^{-5}	1×10^{-7}	7×10^{-9}	3×10^{-8}
		I	1×10^{-5}	9×10^{-8}	5×10^{-9}	3×10^{-8}
	Mn 54	S	4×10^{-5}	4×10^{-7}	1×10^{-8}	1×10^{-8}
		I	4×10^{-5}	3×10^{-7}	1×10^{-8}	1×10^{-8}
	Mn 56	S	8×10^{-5}	4×10^{-7}	3×10^{-8}	1×10^{-8}
		I	5×10^{-5}	3×10^{-7}	2×10^{-8}	1×10^{-8}
Mercury (80)	Hg 197m	S	7×10^{-5}	6×10^{-7}	2×10^{-8}	2×10^{-8}
		I	8×10^{-5}	5×10^{-7}	3×10^{-8}	2×10^{-8}
	Hg 197	S	1×10^{-4}	8×10^{-6}	4×10^{-8}	3×10^{-7}
		I	3×10^{-5}	1×10^{-6}	8×10^{-9}	5×10^{-8}
	Hg 203	S	7×10^{-5}	5×10^{-7}	2×10^{-8}	2×10^{-8}
		I	1×10^{-5}	5×10^{-7}	4×10^{-9}	1×10^{-8}
Molybdenum (42)	Mo 99	S	7×10^{-5}	5×10^{-7}	3×10^{-8}	2×10^{-8}
		I	2×10^{-5}	1×10^{-6}	7×10^{-9}	4×10^{-8}
Neodymium (60)	Nd 144	S	8×10^{-11}	2×10^{-3}	3×10^{-11}	7×10^{-9}
		I	3×10^{-10}	2×10^{-3}	1×10^{-10}	5×10^{-9}
	Nd 147	S	4×10^{-5}	2×10^{-7}	1×10^{-8}	6×10^{-8}
		I	2×10^{-5}	2×10^{-7}	1×10^{-8}	6×10^{-8}
	Nd 149	S	1×10^{-4}	8×10^{-7}	4×10^{-8}	3×10^{-8}
		I	1×10^{-4}	8×10^{-7}	5×10^{-8}	3×10^{-8}
Neptunium (93)	Np 237	S	4×10^{-14}	9×10^{-6}	1×10^{-14}	3×10^{-7}
		I	1×10^{-13}	9×10^{-6}	4×10^{-14}	3×10^{-7}
	Np 239	S	8×10^{-5}	4×10^{-7}	3×10^{-8}	1×10^{-8}
		I	7×10^{-5}	4×10^{-7}	2×10^{-8}	1×10^{-8}
Nickel (28)	Ni 59	S	5×10^{-4}	6×10^{-6}	2×10^{-7}	2×10^{-7}

APPENDIX B—CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—Continued

(See footnotes at end of Appendix B)

Element (atomic number)	Isotope		Table I		Table II	
			Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)	Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)
			8×10^{-7}	6×10^{-3}	3×10^{-9}	2×10^{-4}
	Ni 63	S	6×10^{-6}	8×10^{-4}	2×10^{-7}	3×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-9}	7×10^{-5}
	Ni 65	S	2×10^{-7}	4×10^{-3}	9×10^{-9}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Niobium (Columbium) (41)	Nb 90m	S	1×10^{-7}	1×10^{-3}	4×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
	Nb 95	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	1×10^{-7}	3×10^{-3}	3×10^{-9}	1×10^{-4}
	N2 97	S	8×10^{-6}	3×10^{-3}	2×10^{-7}	1×10^{-4}
		I	5×10^{-6}	3×10^{-3}	2×10^{-7}	9×10^{-5}
Osmium (76)	Os 185	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	5×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
	Os 191m	S	7×10^{-5}	7×10^{-3}	3×10^{-6}	2×10^{-4}
		I	9×10^{-6}	7×10^{-3}	3×10^{-7}	2×10^{-4}
	Os 191	S	1×10^{-6}	5×10^{-4}	4×10^{-8}	2×10^{-5}
		I	4×10^{-7}	5×10^{-4}	1×10^{-8}	2×10^{-5}
	Os 193	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	3×10^{-7}	2×10^{-3}	9×10^{-9}	5×10^{-5}
Palladium (46)	Pd 103	S	1×10^{-6}	1×10^{-3}	5×10^{-8}	3×10^{-5}
		I	7×10^{-7}	8×10^{-4}	3×10^{-8}	3×10^{-5}
	Pd 109	S	8×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
Phosphorus (15)	P 32	S	7×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	6×10^{-8}	7×10^{-4}	3×10^{-9}	2×10^{-5}
Platinum (78)	Pt 191	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Pt 193m	S	7×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
	Pt 193	S	1×10^{-6}	3×10^{-2}	4×10^{-8}	1×10^{-3}
		I	3×10^{-7}	8×10^{-3}	1×10^{-8}	2×10^{-4}
	Pt 197m	S	4×10^{-6}	3×10^{-3}	2×10^{-7}	1×10^{-4}
		I	5×10^{-6}	3×10^{-3}	2×10^{-7}	9×10^{-5}
	Pt 197	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Plutonium (94)	Pu 238	S	2×10^{-12}	1×10^{-7}	7×10^{-14}	5×10^{-9}
		I	3×10^{-11}	8×10^{-7}	1×10^{-12}	3×10^{-8}
	Pu 239	S	2×10^{-12}	1×10^{-7}	6×10^{-14}	5×10^{-9}
		I	4×10^{-11}	9×10^{-7}	1×10^{-12}	3×10^{-8}
	Pu 240	S	2×10^{-12}	1×10^{-7}	6×10^{-14}	5×10^{-9}
		I	4×10^{-11}	9×10^{-7}	1×10^{-12}	3×10^{-8}
	Pu 241	S	9×10^{-10}	7×10^{-5}	3×10^{-11}	2×10^{-6}
		I	4×10^{-9}	4×10^{-5}	1×10^{-10}	1×10^{-6}
	Pu 242	S	2×10^{-12}	1×10^{-7}	6×10^{-14}	5×10^{-9}
		I	4×10^{-11}	9×10^{-7}	1×10^{-12}	3×10^{-8}
	Pu 243	S	2×10^{-6}	1×10^{-3}	5×10^{-8}	3×10^{-5}
		I	2×10^{-6}	1×10^{-3}	6×10^{-8}	3×10^{-5}
	Pu 244	S	2×10^{-12}	1×10^{-7}	6×10^{-14}	4×10^{-9}
		I	3×10^{-11}	3×10^{-7}	1×10^{-12}	1×10^{-7}
Polonium (84)	Po 210	S	5×10^{-10}	2×10^{-5}	2×10^{-11}	7×10^{-7}
		I	2×10^{-10}	6×10^{-5}	7×10^{-12}	2×10^{-6}
Potassium (19)	K 42	S	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	1×10^{-6}	8×10^{-3}	4×10^{-8}	2×10^{-4}
Praseodymium (59)	Pr 142	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
	Pr 143	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	5×10^{-5}
Promethium (61)	Pm 147	S	6×10^{-7}	6×10^{-3}	2×10^{-8}	2×10^{-4}
		I	1×10^{-7}	6×10^{-3}	3×10^{-9}	2×10^{-4}
	Pm 149	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
Protactinium (91)	Pa 230	S	2×10^{-7}	7×10^{-4}	6×10^{-9}	2×10^{-5}
		I	8×10^{-8}	7×10^{-4}	3×10^{-9}	2×10^{-5}
	Pa 231	S	1×10^{-12}	3×10^{-7}	4×10^{-14}	9×10^{-9}
		I	1×10^{-10}	2×10^{-7}	4×10^{-12}	2×10^{-8}

APPENDIX B—CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—Continued

(See footnotes at end of Appendix B)

Element (atomic number)	Isotope		Table I		Table II	
			Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)	Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)
	Pa 233	S	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
		I	2×10^{-7}	3×10^{-3}	8×10^{-9}	1×10^{-4}
Radium (88)	Ra 223	S	2×10^{-8}	2×10^{-4}	8×10^{-10}	7×10^{-6}
		I	2×10^{-10}	1×10^{-4}	5×10^{-12}	4×10^{-6}
	Ra 224	S	5×10^{-8}	7×10^{-4}	2×10^{-9}	2×10^{-5}
		I	3×10^{-10}	2×10^{-4}	2×10^{-11}	6×10^{-6}
	Ra 225	S	3×10^{-11}	4×10^{-5}	3×10^{-12}	9×10^{-7}
		I	5×10^{-11}	9×10^{-5}	2×10^{-12}	3×10^{-6}
	Ra 226	S	7×10^{-11}	8×10^{-5}	2×10^{-12}	3×10^{-6}
		I	4×10^{-11}	7×10^{-5}	1×10^{-12}	2×10^{-6}
Radon (86)	Rn 220	S	2×10^{-7}		1×10^{-8}	
	Rn 222	S	2×10^{-8}		7×10^{-10}	
Rhenium (75)	Re 183	S	3×10^{-6}	2×10^{-3}	9×10^{-8}	6×10^{-5}
		I	2×10^{-6}	8×10^{-4}	8×10^{-8}	3×10^{-5}
	Re 186	S	8×10^{-7}	2×10^{-3}	2×10^{-8}	9×10^{-5}
		I	2×10^{-7}	1×10^{-3}	5×10^{-9}	5×10^{-5}
	Re 187	S	8×10^{-6}	7×10^{-3}	3×10^{-7}	3×10^{-4}
		I	5×10^{-6}	4×10^{-3}	2×10^{-7}	2×10^{-4}
	Re 188	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
Rhodium (45)	Rh 105m	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Rh 106	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
Rubidium (37)	Rb 86	S	7×10^{-7}	7×10^{-4}	2×10^{-8}	2×10^{-5}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Rb 87	S	7×10^{-7}	5×10^{-3}	2×10^{-8}	2×10^{-4}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
Ruthenium (44)	Ru 97	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	3×10^{-5}
		I	5×10^{-7}	2×10^{-3}	2×10^{-8}	6×10^{-5}
	Ru 103	S	8×10^{-7}	2×10^{-3}	3×10^{-8}	8×10^{-5}
		I	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Ru 105	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	5×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
	Ru 106	S	1×10^{-7}	1×10^{-4}	4×10^{-9}	4×10^{-6}
		I	8×10^{-8}	1×10^{-4}	3×10^{-9}	4×10^{-6}
Samarium (62)	Sm 147	S	7×10^{-12}	2×10^{-7}	2×10^{-13}	6×10
		I	3×10^{-10}	2×10^{-7}	9×10^{-12}	7×10^{-9}
	Sm 151	S	6×10^{-6}	1×10^{-3}	2×10^{-7}	4×10^{-5}
		I	1×10^{-6}	1×10^{-3}	5×10^{-8}	4×10^{-5}
	Sm 153	S	6×10^{-7}	2×10^{-3}	2×10^{-8}	6×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Scandium (21)	Sc 46	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
	Sc 47	S	8×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	8×10^{-5}
	Sc 48	S	2×10^{-7}	6×10^{-4}	6×10^{-9}	2×10
		I	1×10^{-7}	8×10^{-4}	3×10^{-9}	3×10^{-5}
Selenium (34)	Se [illegible]	S	1×10^{-7}	9×10^{-4}	4×10^{-9}	3×10^{-5}
		I	1×10^{-7}	9×10^{-4}	4×10^{-9}	3×10^{-5}
Silicon (14)	Si 31	S	6×10^{-7}	2×10^{-3}	2×10^{-8}	9×10^{-5}
		I	1×10^{-6}	6×10^{-3}	5×10^{-8}	2×10^{-4}
Silver (47)	Ag 105	S	8×10^{-7}	2×10^{-3}	2×10^{-8}	1×10^{-4}
		I	8×10^{-7}	3×10^{-3}	3×10^{-8}	1×10^{-4}
	Ag 110m	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	1×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
	Ag 111	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Sodium (11)	Na 22	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
	Na 24	S	1×10^{-7}	8×10^{-4}	4×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	4×10^{-9}	3×10^{-5}
Strontium (38)	Sr 85m	S	1×10^{-6}	6×10^{-3}	5×10^{-8}	2×10^{-4}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
	Sr 85	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	2×10^{-7}	3×10^{-3}	8×10^{-9}	1×10^{-4}

APPENDIX B—CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—Continued

(See footnotes at end of Appendix B)

Element (atomic number)	Isotope [1]		Table I		Table II	
			Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)	Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)
	Sr 85	S	1×10^{-7}	6×10^{-7}	4×10^{-7}	2×10^{-6}
		I	3×10^{-8}	3×10^{-7}	2×10^{-7}	2×10^{-6}
	Sr 89	S	4×10^{-8}	6×10^{-8}	1×10^{-7}	3×10^{-7}
		I	1×10^{-8}	1×10^{-7}	3×10^{-7}	3×10^{-7}
	Sr 90	S	6×10^{-9}	1×10^{-7}	2×10^{-8}	4×10^{-7}
		I	4×10^{-7}	2×10^{-6}	2×10^{-6}	7×10^{-6}
	Sr 91	S	3×10^{-7}	1×10^{-6}	9×10^{-7}	4×10^{-6}
		I	4×10^{-7}	2×10^{-6}	2×10^{-6}	7×10^{-6}
	Sr 92	S	3×10^{-7}	2×10^{-6}	1×10^{-6}	6×10^{-6}
Sulfur (16)	S 35	S	9×10^{-8}	2×10^{-6}	3×10^{-7}	6×10^{-6}
		I	3×10^{-7}	8×10^{-6}	9×10^{-7}	3×10^{-5}
Tantalum (73)	Ta 182	S	4×10^{-8}	1×10^{-7}	1×10^{-7}	4×10^{-7}
Technetium (43)	Tc 96m	S	2×10^{-6}	1×10^{-5}	7×10^{-6}	4×10^{-5}
		I	6×10^{-6}	4×10^{-5}	2×10^{-5}	1×10^{-4}
	Tc 96	S	5×10^{-8}	3×10^{-7}	1×10^{-7}	1×10^{-6}
		I	6×10^{-8}	3×10^{-7}	2×10^{-7}	1×10^{-6}
	Tc 97m	S	2×10^{-7}	1×10^{-6}	8×10^{-7}	5×10^{-6}
		I	2×10^{-7}	1×10^{-6}	6×10^{-7}	4×10^{-6}
	Tc 97	S	2×10^{-7}	1×10^{-6}	6×10^{-7}	2×10^{-6}
		I	1×10^{-7}	4×10^{-7}	4×10^{-7}	2×10^{-6}
	Tc 98m	S	8×10^{-7}	3×10^{-6}	1×10^{-6}	5×10^{-6}
		I	4×10^{-7}	2×10^{-6}	1×10^{-6}	6×10^{-6}
	Tc 99	S	1×10^{-7}	6×10^{-7}	5×10^{-7}	3×10^{-6}
		I	5×10^{-8}	1×10^{-6}	2×10^{-7}	3×10^{-6}
	Tc 99m	S	5×10^{-6}	3×10^{-5}	2×10^{-5}	8×10^{-5}
Tellurium (52)	Te 125m	S	4×10^{-8}	6×10^{-8}	1×10^{-7}	2×10^{-7}
		I	1×10^{-7}	3×10^{-7}	4×10^{-7}	1×10^{-6}
	Te 127m	S	1×10^{-7}	2×10^{-7}	5×10^{-7}	6×10^{-7}
		I	4×10^{-8}	2×10^{-7}	1×10^{-7}	5×10^{-7}
	Te 127	S	2×10^{-7}	9×10^{-7}	6×10^{-7}	3×10^{-6}
		I	8×10^{-7}	5×10^{-6}	3×10^{-6}	2×10^{-5}
	Te 129m	S	3×10^{-8}	1×10^{-7}	2×10^{-7}	5×10^{-7}
		I	3×10^{-8}	6×10^{-8}	1×10^{-7}	2×10^{-7}
	Te 129	S	5×10^{-6}	2×10^{-5}	2×10^{-5}	8×10^{-5}
		I	4×10^{-6}	2×10^{-5}	1×10^{-5}	6×10^{-5}
	Te 131m	S	4×10^{-7}	2×10^{-6}	1×10^{-6}	6×10^{-6}
		I	7×10^{-7}	3×10^{-6}	2×10^{-6}	1×10^{-5}
	Te 132	S	2×10^{-7}	9×10^{-7}	7×10^{-7}	3×10^{-6}
		I	1×10^{-7}	8×10^{-7}	4×10^{-7}	2×10^{-6}
Terbium (65)	Tb 160	S	1×10^{-7}	1×10^{-6}	3×10^{-7}	4×10^{-6}
Thallium (81)	Tl 200	S	9×10^{-8}	1×10^{-6}	1×10^{-7}	4×10^{-6}
		I	3×10^{-7}	1×10^{-6}	9×10^{-7}	4×10^{-6}
	Tl 201	S	1×10^{-7}	7×10^{-7}	4×10^{-7}	2×10^{-6}
		I	2×10^{-7}	9×10^{-7}	7×10^{-7}	3×10^{-6}
	Tl 202	S	9×10^{-8}	5×10^{-7}	3×10^{-7}	2×10^{-6}
		I	5×10^{-8}	4×10^{-7}	3×10^{-7}	1×10^{-6}
	Tl 204	S	2×10^{-7}	2×10^{-6}	8×10^{-7}	7×10^{-6}
		I	6×10^{-8}	3×10^{-7}	2×10^{-7}	1×10^{-6}
Thorium (90)	Th 227	S	3×10^{-8}	2×10^{-6}	8×10^{-8}	6×10^{-6}
		I	3×10^{-14}	5×10^{-11}	1×10^{-13}	2×10^{-10}
	Th 228	S	2×10^{-10}	5×10^{-9}	6×10^{-10}	2×10^{-8}
		I	6×10^{-14}	2×10^{-11}	3×10^{-13}	7×10^{-11}
	Th 230	S	2×10^{-9}	4×10^{-8}	2×10^{-8}	1×10^{-7}
		I	2×10^{-14}	5×10^{-11}	1×10^{-13}	2×10^{-10}
	Th 231	S	1×10^{-6}	3×10^{-5}	3×10^{-6}	1×10^{-4}
		I	1×10^{-6}	7×10^{-6}	3×10^{-6}	2×10^{-5}
	Th 232	S	3×10^{-14}	6×10^{-11}	1×10^{-13}	2×10^{-10}
		I	8×10^{-14}	6×10^{-11}	2×10^{-13}	3×10^{-10}
	Th (natural)	S	4×10^{-9}	5×10^{-8}	1×10^{-8}	2×10^{-7}
		I	3×10^{-9}	5×10^{-8}	1×10^{-8}	2×10^{-7}
	Th 234	S	4×10^{-7}	1×10^{-6}	1×10^{-6}	5×10^{-6}
Thulium (69)	Tm 170	S	3×10^{-8}	1×10^{-6}	1×10^{-7}	5×10^{-6}

APPENDIX B—CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—Continued

(See footnotes at end of Appendix B)

Element (atomic number)	Isotope		Table I		Table II	
			Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)	Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)
	Tm 171	S	1×10^{-6}	1×10^{-5}	4×10^{-6}	5×10^{-5}
Tin (50)	Sn 113	S	2×10^{-7}	1×10^{-6}	9×10^{-7}	5×10^{-6}
		I	4×10^{-8}	2×10^{-7}	1×10^{-7}	8×10^{-7}
	Sn 125	S	8×10^{-8}	2×10^{-7}	2×10^{-7}	8×10^{-7}
		I	1×10^{-7}	5×10^{-7}	4×10^{-7}	2×10^{-6}
Tungsten (Wolfram) (74)	W 181	S	6×10^{-7}	5×10^{-6}	3×10^{-6}	2×10^{-5}
		I	2×10^{-7}	1×10^{-6}	8×10^{-7}	4×10^{-6}
	W 185	S	1×10^{-6}	1×10^{-5}	4×10^{-6}	3×10^{-5}
		I	6×10^{-7}	4×10^{-6}	3×10^{-6}	1×10^{-5}
	W 187	S	1×10^{-6}	3×10^{-6}	4×10^{-6}	1×10^{-5}
		I	4×10^{-7}	2×10^{-6}	2×10^{-6}	7×10^{-6}
Uranium (92)	U 230	S	2×10^{-10}	2×10^{-9}	1×10^{-9}	6×10^{-9}
		I	3×10^{-11}	1×10^{-9}	1×10^{-10}	5×10^{-9}
	U 232	S	1×10^{-10}	1×10^{-9}	4×10^{-10}	5×10^{-9}
		I	3×10^{-12}	9×10^{-11}	1×10^{-11}	3×10^{-10}
	U 233	S	5×10^{-10}	4×10^{-9}	2×10^{-9}	1×10^{-8}
		I	1×10^{-11}	8×10^{-11}	3×10^{-11}	3×10^{-10}
	U 234	S*	5×10^{-10}	4×10^{-9}	2×10^{-9}	1×10^{-8}
		I	1×10^{-11}	8×10^{-11}	3×10^{-11}	3×10^{-10}
	U 235	S*	6×10^{-10}	4×10^{-9}	2×10^{-9}	1×10^{-8}
		I	1×10^{-11}	9×10^{-11}	3×10^{-11}	3×10^{-10}
	U 236	S	6×10^{-10}	4×10^{-9}	2×10^{-9}	1×10^{-8}
		I	1×10^{-11}	9×10^{-11}	3×10^{-11}	3×10^{-10}
	U 238	S*	7×10^{-10}	5×10^{-9}	2×10^{-9}	1×10^{-8}
		I	1×10^{-11}	1×10^{-10}	4×10^{-11}	4×10^{-10}
	U 240	S	2×10^{-7}	1×10^{-6}	8×10^{-7}	4×10^{-6}
		I	2×10^{-7}	1×10^{-6}	8×10^{-7}	4×10^{-6}
	U (natural)	S*	1×10^{-9}	1×10^{-8}	4×10^{-9}	2×10^{-8}
		I	6×10^{-10}	8×10^{-9}	2×10^{-9}	3×10^{-8}
Vanadium (23)	V 48	S	2×10^{-7}	6×10^{-7}	4×10^{-7}	2×10^{-6}
Xenon (54)	Xe 131m	Sub	1×10^{-6}		3×10^{-6}	
	Xe 133	Sub	1×10^{-6}		3×10^{-6}	
	Xe 133m	Sub	1×10^{-6}		3×10^{-6}	
	Xe 135	Sub	4×10^{-6}		1×10^{-5}	
Ytterbium (70)	Yb 175	S	7×10^{-7}	3×10^{-6}	2×10^{-6}	1×10^{-5}
Yttrium (39)	Y 87	S	8×10^{-8}	3×10^{-7}	2×10^{-7}	1×10^{-6}
	Y 90m	S	1×10^{-6}	6×10^{-6}	4×10^{-6}	2×10^{-5}
	Y 90	S	2×10^{-8}	1×10^{-7}	5×10^{-8}	3×10^{-7}
	Y 91m	S	2×10^{-7}	1×10^{-6}	8×10^{-7}	3×10^{-6}
	Y 91	S	4×10^{-9}	2×10^{-8}	1×10^{-8}	5×10^{-8}
	Y 92	S	4×10^{-7}	2×10^{-6}	1×10^{-6}	5×10^{-6}
	Y 93	S	2×10^{-8}	1×10^{-7}	6×10^{-8}	3×10^{-7}
Zinc (30)	Zn 65	S	3×10^{-8}	2×10^{-7}	1×10^{-7}	6×10^{-7}
		I	6×10^{-8}	4×10^{-7}	2×10^{-7}	1×10^{-6}
	Zn 69m	S	1×10^{-7}	6×10^{-7}	4×10^{-7}	2×10^{-6}
		I	3×10^{-7}	2×10^{-6}	1×10^{-6}	7×10^{-6}
	Zn 69	S	7×10^{-7}	5×10^{-6}	2×10^{-6}	2×10^{-5}
		I	8×10^{-6}	6×10^{-5}	3×10^{-5}	2×10^{-4}
Zirconium (40)	Zr 93	S	1×10^{-7}	8×10^{-7}	4×10^{-7}	3×10^{-6}
		I	2×10^{-7}	1×10^{-6}	6×10^{-7}	4×10^{-6}
	Zr 95	S	1×10^{-7}	9×10^{-7}	4×10^{-7}	3×10^{-6}
		I	2×10^{-7}	1×10^{-6}	6×10^{-7}	4×10^{-6}
	Zr 97	S	5×10^{-8}	3×10^{-7}	2×10^{-7}	1×10^{-6}
		I	9×10^{-8}	6×10^{-7}	3×10^{-7}	2×10^{-6}
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours.		Sub	1×10^{-6}		3×10^{-6}	

APPENDIX B—CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—Continued

(See comments at end of Appendix B)

Element (atomic number)	Solubility [1]	Table I		Table II	
		Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)	Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours		3×10^{-7}	8×10^{-3}	1×10^{-8}	3×10^{-4}
Any single radionuclide not listed above, which decays by alpha emission or spontaneous fission		8×10^{-11}	4×10^{-7}	7×10^{-12}	3×10^{-8}

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

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

[3] These certain concentrations are appropriate for protection from radon-222 corrected + for its short-lived daughters. Alternatively, the value in Table I may be restated by one-third (⅓) "working level" (1 "working level" is defined as any combination of short-lived radon-222 daughters — polonium-218, lead-214, bismuth-214 and polonium-214, in one liter of air without regard to the degree of equilibrium that will result in the ultimate emission of 1.3×10^5 MeV of alpha particle energy). The Table II value may be replaced by one-twelfth (1/12) of a "working level". The limit on radon-222 concentrations in occupied areas may be based on an annual average.

For soluble mixtures of U-238, U-234 and U-235 in an chemical toxicity may be the limiting factor. If the percent by weight (enrichment) of U-235 is less than 5, the concentration value for a 40-hour workweek (Table I, is 0.2 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8×10^{-4} SA μCi-hr/ml, where SA is the specific activity of the uranium inhaled. The concentration value for Table II is 0.007 milligrams uranium per cubic meter of air. The specific activity for natural uranium is 6.77×10^{-7} curies per gram U. The specific activity for other mixtures of U-238, U-235, and U-234, if not known, shall be:

SA = $(0.4 + 0.38 E + 0.034 E^2) \times 10^{-6}$ Ci/gm U (depleted)

SA = $(2.9 + 0.38 E + 0.034 E^2) \times 10^{-6}$ Ci/gm U (natural)

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

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

1. If the identity and concentration of each radionuclide in the mixture are known, the limiting values should be derived as follows: Determine, for each radionuclide in the mixture, the ratio between the quantity present in the mixture and the limit otherwise established in Appendix B for the specific radionuclide when not in a mixture. The sum of such ratios for all the radionuclides in the mixture may not exceed "1" (i.e., "unity").

Example: If radionuclides A, B, and C are present in concentrations C_A, C_B, and C_C, and if the applicable MPC's are MPC_A, 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 one radionuclide in the mixture is not known, the limiting values for purposes of Appendix B shall be:

a. For purposes of S_a Air (Table I, Col. 1)—8×10^{-14}

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

c. For purposes of Table II, Col. 1—2×10^{-12}

d. For purposes of Table II, Col. 2—3×10^{-8}

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

Element (atomic number) and isotope	Table I		Table II	
	Col. 1—Air ($\mu Ci/ml$)	Col. 2—Water ($\mu Ci/ml$)	Col. 1—Air ($\mu Ci/ml$)	Col. 2—Water ($\mu Ci/ml$)
If it is known that Sr-90, I-125, I-126, I-129, I-131 (I-133, Table II only), Pb-210, Po-210, At-211, Ra-223, Ra-224, Ra-226, Ac-227, Ra-228, Th-230, Pa-231, Th-232, Th-nat, Cm-242, Cf-254, and Fm-256 are not present		9×10^{-4}		3×10^{-4}
If it is known that Sr-90, I-125, I-126, I-129, I-131, I-133, Table II only), Pu-210, Po-210, Ra-223, Ra-224, Ra-226, Pa-231, Th-nat, Cm-248, Cf-254, and Fm-260 are not present		8×10^{-4}		2×10^{-4}
If it is known that Sr-90, I-129 (I-125, I-126, I-131, Table II only), Pb-210, Ra-226, Ra-228, Cm-248, and Cf-254 are not present		2×10^{-4}		6×10^{-5}
If it is known that I-129, Table II only), Ra-226, and Ra-228 are not present		3×10^{-5}		1×10^{-5}
If it is known that alpha-emitters and Sr-90, I-129, Pb-210, Ac-227, Ra-228, Pa-230, Pu-241, and Bk-249 are not present	3×10^{-4}		1×10^{-4}	

Element (atomic number) and isotope	Table I		Table II	
	Col. 1—Air ($\mu Ci/ml$)	Col. 2—Water ($\mu Ci/ml$)	Col. 1—Air ($\mu Ci/ml$)	Col. 2—Water ($\mu Ci/ml$)
If it is known that alpha-emitters and Pb-210, Ac-227, Ln-228, and Pu-241 are not present	2×10^{-14}		1×10^{-15}	
If it is known that alpha-emitters and I-227 are not present	3×10^{-13}		1×10^{-14}	
If it is known that Ac-227, Th-nat, Pa-231, Pu-238, Pu-239, Pu-240, Pu-242, Pu-244, Cm-248, Cf-249 and Cf-251 are not present	3×10^{-14}		1×10^{-15}	

[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—3×10^{-12} μCi/ml gross alpha activity or 6×10^{-10} μCi/ml natural uranium or 0.1 micrograms per cubic meter of air natural uranium.

b. For purposes of Table II, Col. 1—3×10^{-13} μCi/ml gross alpha activity, 2×10^{-10} μCi/ml natural uranium, or 3 micrograms 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 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" (MPC_A) does not exceed 1/10, (i.e., $C_A/MPC_A \leq 1/10$) and (b) the sum of such ratios for all the radionuclides considered as not present in the mixture does not exceed "1" i.e.

(c) $\sum MPC_A + C_B/MPC_B + \ldots \leq 0.1$.

[25 FR 10914, Nov. 17, 1960, as amended at 28 FR 12983, Dec. 30, 1963; 29 FR 11046, Nov. 25, 1964; 29 FR 14435, Oct. 21, 1964; 30 FR 15801, Dec. 22, 1965; 31 FR 86, Jan. 5, 1966; 37 FR 23319, Nov. 2, 1972; 38 FR 28514, Oct. 24, 1973; 39 FR 22990, June 28, 1974; 39 FR 25463, July 11, 1974; 39 FR 27121, July 25, 1974; 40 FR 50705, Oct. 31, 1975]

APPENDIX C—Continued

APPENDIX C

Material	Allowable air
Americium-241	01
Antimony-122	100
Antimony-124	10
Antimony-125	0
Antimony-126	100
Arsenic-73	10
Arsenic-74	10
Arsenic-76	10
Arsenic-77	100
Barium-131	10
Barium-133	10
Barium-140	10
Bismuth-210	1
Bromine-82	10
Cadmium-109	10
Cadmium-115m	10
Cadmium-115	100
Calcium-45	10
Calcium-47	10
Carbon-14	10
Cerium-141	100
Cerium-143	100
Cerium-144	1
Cesium-131	1,000
Cesium-134m	100
Cesium-134	1
Cesium-135	10
Cesium-136	10
Cesium-137	10
Chlorine-36	10
Chlorine-38	10
Chromium-51	1,000
Cobalt-58m	10
Cobalt-58	10
Cobalt-60	1
Copper-64	100
Dysprosium-165	10
Dysprosium-166	100

Material	Allowable air
Erbium-169	100
Erbium-171	100
Europium-152 9.2 h	100
Europium-152 13 yr	1
Europium-154	1
Europium-155	10
Fluorine-18	1,000
Gadolinium-153	10
Gadolinium-159	100
Gallium-72	10
Germanium-71	100
Gold-196	100
Gold-199	100
Hafnium-181	10
Hafnium-182	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	1
Iodine-131	1
Iodine-132	10
Iodine-133	1
Iodine-134	10
Iodine-135	10
Iridium-192	100
Iridium-194	100
Iron-55	10
Iron-59	100
Krypton-85	10
Krypton-87	10
Lanthanum-140	100
Lutetium-177	10
Manganese-52	10
Manganese-54	10

APPENDIX C—Continued

Material	Microcurie per
Manganese-56	10
Mercury-197m	100
Mercury-197	100
Mercury-203	10
Molybdenum-99	100
Neodymium-147	100
Neodymium-149	100
Nickel-59	100
Nickel-63	10
Nickel-65	100
Niobium-93m	10
Niobium-95	10
Niobium-97	10
Osmium-185	10
Osmium-191m	100
Osmium-191	100
Osmium-193	100
Palladium-103	100
Palladium-109	100
Phosphorus-32	10
Platinum-191	100
Platinum-193m	100
Platinum-193	100
Platinum-197m	100
Platinum-197	100
Plutonium-239	0*
Polonium-210	0.1
Potassium-42	10
Praseodymium-142	100
Praseodymium-143	100
Promethium-147	10
Promethium-149	10
Radium-226	01
Rhenium-186	100
Rhenium-188	100
Rhodium-103m	100
Rhodium-105	100
Rubidium-86	10
Ruthenium-97	10
Ruthenium-103	10
Ruthenium-105	10
Ruthenium-106	1
Samarium-151	10
Samarium-153	100
Scandium-46	10
Scandium-47	100
Scandium-48	10
Selenium-75	10
Silicon-31	100
Silver-105	10
Silver-110m	1
Silver-111	100
Sodium-24	10
Strontium-85	10
Strontium-89	1
Strontium-90	0.1
Strontium-91	10
Strontium-92	10
Sulphur-35	100
Tantalum-182	10
Technetium-96	10
Technetium-97m	10
Technetium-97	100
Technetium-99m	100
Technetium-99	10
Tellurium-125m	10

APPENDIX C—Continued

Material	Microcurie per
Tellurium-127m	10
Tellurium-127	100
Tellurium-129m	10
Tellurium-12	100
Tellurium-131m	10
Tellurium-132	10
Terbium-160	10
Thallium-200	100
Thallium-201	100
Thallium-202	100
Thallium-204	10
Thorium (natural)	100
Thulium-170	10
Thulium-171	10
Tin-113	10
Tin-125	10
Tungsten-181	10
Tungsten-185	10
Tungsten-187	100
Uranium (natural)*	100
Uranium-233	01
Uranium-234—Uranium-235	01
Vanadium-48	10
Xenon-131m	1,000
Xenon-133	100
Xenon-135	100
Ytterbium-175	100
Yttrium-90	10
Yttrium-91	10
Yttrium-92	100
Yttrium-93	100
Zinc-65	10
Zinc-69m	100
Zinc-69	1,000
Zirconium-93	10
Zirconium-95	10
Zirconium-97	10
Any alpha emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	01
Any radionuclide other than alpha emitting radionuclides, not listed above or mixtures of beta emitters of unknown composition	1

*Based on alpha disintegration rate of Th-232, Th-230 and their daughter products.
*Based on alpha disintegration rate of U-238, U-234, and U-235.

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

[35 FR 6425, Apr. 22, 1970, as amended at 36 FR 16898, Aug. 26, 1971; 38 FR 29314, Oct. 24, 1973; 39 FR 23991, June 28, 1974; 45 FR 71153, Oct. 30, 1980]

APPENDIX D—U.S. NUCLEAR REGULATORY COMMISSION REGIONAL OFFICES

	Addressee	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) 337-5049 (FTS) 488-1300
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) 790-5540 (FTS) 388-5540
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) 729-8100
Region IV Field Office	USNRC, Region IV Uranium Recovery Field Office, 730 Simms Street, P.O. Box 25325, Denver, CO 80225	(303) 236-2805 (FTS) 776-2805
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) 460-3700

[49 FR 47823, Dec. 7, 1984, as amended at 50 FR 46631, Nov. 12, 1985; 51 FR 35500, Oct. 6, 1986]

U.S. NUCLEAR REGULATORY COMMISSION

Revision 2
December 1987

REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 8.13
(Task OP 031-4)

INSTRUCTION CONCERNING PRENATAL RADIATION EXPOSURE

A. INTRODUCTION

Section 19.12, "Instructions to Workers," of 10 CFR Part 19, "Notices, Instructions, and Reports to Workers; Inspections," requires that all individuals working in or frequenting any portion of a restricted area[1] be instructed in the health protection problems associated with exposure to radioactive materials or radiation, in precautions or procedures to minimize exposure, and in the regulations that they are expected to observe. The present 10 CFR Part 20, "Standards for Protection Against Radiation," has no special limit for exposure of the embryo/fetus.[2] This guide describes the instructions an employer should provide to workers and supervisors concerning biological risks to the embryo/fetus exposed to radiation, a dose limit for the embryo/fetus that is under consideration, and suggestions for reducing radiation exposure.

This regulatory guide takes into consideration a proposed revision to 10 CFR Part 20, which incorporates the radiation protection guidance for the embryo/fetus approved by the President in January 1987 (Ref. 1). This revision to Part 20 was issued in January 1986 for comment as a proposed rule. Comments on the guide as it pertains to the proposed Part 20 are encouraged. If the new Part 20 is codified, this regulatory guide will be revised to conform to the new regulation and will incorporate appropriate public comments.

Any information collection activities mentioned in this regulatory guide are contained as requirements in 10 CFR Parts 19 or 20, which provide the regulatory basis for this guide. The information collection requirements in 10 CFR Parts 19 and 20 have been cleared under OMB Clearance Nos. 3150-0044 and 3150-0014, respectively.

B. DISCUSSION

It has been known since 1906 that cells that are dividing very rapidly and are undifferentiated in their structure and function are generally more sensitive to radiation. In the embryo stage, cells meet both these criteria and thus would be expected to be highly sensitive to radiation. Furthermore, there is direct evidence that the embryo/fetus is radiosensitive. There is also evidence that it is especially sensitive to certain radiation effects during certain periods after conception, particularly during the first 2 to 3 months after conception when a woman may not be aware that she is pregnant.

Section 20.104 of 10 CFR Part 20 places different radiation dose limits on workers who are minors than on adult workers. Workers under the age of 18 are limited to one-tenth of the adult radiation dose limits. However, the present NRC regulations do not establish dose limits specifically for the embryo/fetus.

The NRC's present limit on the radiation dose that can be received on the job is 1,250 millirems per quarter (3 months).[3] Working minors (those under 18) are limited to a dose equal to one-tenth that of adults, 125 millirems per quarter. (See § 20.101 of 10 CFR Part 20.)

Because of the sensitivity of the unborn child, the National Council on Radiation Protection and Measurements (NCRP) has recommended that the dose equivalent

[1] Restricted area means any area that has controlled access to protect individuals from being exposed to radiation and radioactive materials.

[2] In conformity with the proposed revision to 10 CFR Part 20, the term "embryo/fetus" is used throughout this document to represent all stages of pregnancy.

[3] The limit is 3,000 millirems per quarter if the worker's occupational dose history is known and the average dose does not exceed 5,000 millirems per year.

to the unborn child from occupational exposure of the expectant mother be limited to 500 millirems for the entire pregnancy (Ref. 2). The 1987 Presidential guidance (Ref. 1) specifies an effective dose equivalent limit of 500 millirems to the unborn child if the pregnancy has been declared by the mother; the guidance also recommends that substantial variations in the rate of exposure be avoided. The NRC (in § 20.208 of its proposed revision to Part 20) has proposed adoption of the above limits on dose and rate of exposure.

In 1971, the NCRP commented on the occupational exposure of fertile women (Ref. 2) and suggested that fertile women should be employed only where the annual dose would be unlikely to exceed 2 or 3 rems and would be accumulated at a more or less steady rate. In 1977, the ICRP recommended that, when pregnancy has been diagnosed, the woman work only where it is unlikely that the annual dose would exceed 0.30 of the dose-equivalent limit of 5 rems (Ref. 3). In other words, the ICRP has recommended that pregnant women not work where the annual dose might exceed 1.5 rem.

C. REGULATORY POSITION

Instructions on radiation risks should be provided to workers, including supervisors, in accordance with § 19.12 of 10 CFR Part 19 before they are allowed to work in a restricted area. In providing instructions on radiation risks, employers should include specific instructions about the risks of radiation exposure to the embryo/fetus.

The instructions should be presented both orally and in printed form, and the instructions should include, as a minimum, the information provided in Appendix A (Instructor's Guide) to this guide. Individuals should be given the opportunity to ask questions and in turn should be questioned to determine whether they understand the instructions. An acceptable method of ensuring that the information is understood is to give a simple written test covering the material included in Appendix B (Pregnant Worker's Guide). This approach should highlight for instructors those parts of the instructions that cause difficulties and thereby lead to appropriate modifications in the instructional curriculum.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

Except in those cases in which an applicant or licensee proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the NRC will use the material described in this guide to evaluate the instructional program presented to individuals, including supervisors, working in or frequenting any portion of a restricted area.

APPENDIX A

INSTRUCTOR'S GUIDE

EFFECTS ON THE EMBRYO/FETUS OF EXPOSURE TO RADIATION AND OTHER ENVIRONMENTAL HAZARDS

In order to decide whether to continue working while exposed to ionizing radiation during her pregnancy, a woman should understand the potential effects on an embryo/fetus, including those that may be produced by various environmental risks such as smoking and drinking. This will allow her to compare these risks with those produced by exposure to ionizing radiation.

Table 1 provides information on the potential effects resulting from exposure of an embryo/fetus to radiation and nonradiation risks. The second column gives the rate at which the effect is produced by natural causes in terms of the number per thousand cases. The fourth column gives the number of additional effects per thousand cases believed to be produced by exposure to the specified amount of the risk factor.

The following section discusses the studies from which the information in Table 1 was derived. The results of exposure of the embryo/fetus to the risk factors and the dependence on the amount of the exposure are explained.

1. RADIATION RISKS

1.1 Childhood Cancer

Numerous studies of radiation-induced childhood cancer have been performed, but a number of them are controversial. The National Academy of Science (NAS) BEIR report reevaluated the data from these studies and even reanalyzed the results. Some of the strongest support for a causal relationship is provided by twin data from the Oxford survey (Ref. 4). For maternal radiation doses of 1,000 millirems, the excess number of deaths (above those occurring from natural causes) was found to be 0.6 death per thousand children (Ref. 4).

1.2 Mental Retardation and Abnormal Smallness of the Head (Microcephaly)

Studies of Japanese children who were exposed while in the womb to the atomic bomb radiation at Hiroshima and Nagasaki have shown evidence of both small head size and mental retardation. Most of the children were exposed to radiation doses in the range of 1 to 50 rads. The importance of the most recent study lies in the fact that investigators were able to show that the gestational age (age of the embryo/fetus after conception) at the time the children were exposed was a critical factor (Ref. 7). The approximate risk of small head size as a function of gestational age is shown in Table 1. For a radiation dose of 1,000 millirems at 4 to 7 weeks after conception, the excess cases of small head size was 5 per thousand; at 8 to 11 weeks, it was 9 per thousand (Ref. 7).

In another study, the highest risk of mental retardation occurred during the 8 to 15 week period, after conception (Ref. 8). A recent EPA study (Ref. 16) has calculated that excess cases of mental retardation per live birth lie between 0.5 and 4 per thousand per rad.

1.3 Genetic Effects

Radiation-induced genetic effects have not been observed to date in humans. The largest source of material for genetic studies involves the survivors of Hiroshima and Nagasaki, but the 77,000 births that occurred among the survivors showed no evidence of genetic effects. For doses received by the pregnant worker in the course of employment considered in this guide, the dose received by the embryo/fetus apparently would have a negligible effect on descendants (Refs. 17 and 18).

2. NONRADIATION RISKS

2.1 Occupation

A recent study (Ref. 9) involving the birth records of 130,000 children in the State of Washington indicates that the risk of death to the unborn child is related to the occupation of the mother. Workers in the metal industry, the chemical industry, medical technology, the wood industry, the textile industry, and farms exhibited stillbirths or spontaneous abortions at a rate of 90 per thousand above that of workers in the control group, which consisted of workers in several other industries.

2.2 Alcohol

It has been recognized since ancient times that alcohol consumption had an effect on the unborn child. Carthaginian law forbade the consumption of wine on the wedding night so that a defective child might not be conceived. Recent studies have indicated that small amounts of alcohol consumption have only the minor effect of reducing the birth weight slightly, but when consumption increases to 2 to 4 drinks per day, a pattern of abnormalities called the fetal alcohol syndrome (FAS) begins to appear (Ref. 11). This syndrome consists of reduced growth in the unborn child, faulty brain function, and abnormal facial features. There is a syndrome that has the same symptoms as full-blown FAS that occurs in children born to mothers who have not consumed alcohol. This naturally occurring syndrome occurs in about 1 to 2 cases per thousand (Ref. 10).

TABLE 1

EFFECTS OF RISK FACTORS ON PREGNANCY OUTCOME

Effect	Number Occurring from Natural Causes	Risk Factor	Excess Occurrences from Risk Factor
		RADIATION RISKS	
		Childhood Cancer	
Cancer death in children	1.4 per thousand (Ref. 5)	Radiation dose of 1000 millirems received before birth	0.6 per thousand (Ref. 4)
		Abnormalities	
		Radiation dose of 1000 millirads received during specific periods after conception:	
Small head size	40 per thousand (Ref. 6)	4-7 weeks after conception	5 per thousand (Ref. 7)
Small head size	40 per thousand (Ref. 6)	8-11 weeks after conception	9 per thousand (Ref. 7)
Mental retardation	4 per thousand (Ref. 8)	Radiation dose of 1000 millirads received 8 to 15 weeks after conception	4 per thousand (Ref. 8)
		NONRADIATION RISKS	
		Occupation	
Stillbirth or spontaneous abortion	200 per thousand (Ref. 9)	Work in high-risk occupations (see text)	90 per thousand (Ref. 9)
		Alcohol Consumption (see text)	
Fetal alcohol syndrome	1 to 2 per thousand (Ref. 10)	2-4 drinks per day	100 per thousand (Ref. 11)
Fetal alcohol syndrome	1 to 2 per thousand (Ref. 10)	More than 4 drinks per day	200 per thousand (Ref. 11)
Fetal alcohol syndrome	1 to 2 per thousand (Ref. 10)	Chronic alcoholic (more than 10 drinks per day)	350 per thousand (Ref. 12)
Perinatal infant death (around the time of birth)	23 per thousand (Refs. 13, 14)	Chronic alcoholic (more than 10 drinks per day)	170 per thousand (Ref. 15)
		Smoking	
Perinatal infant death	23 per thousand (Refs. 13, 14)	Less than 1 pack per day	5 per thousand (Ref. 13)
Perinatal infant death	23 per thousand (Refs. 13, 14)	One pack or more per day	10 per thousand (Ref. 13)

For mothers who consume 2 to 4 drinks per day, the excess occurrences number about 100 per thousand; and for those who consume more than 4 drinks per day, excess occurrences number 200 per thousand. The most sensitive period for this effect of alcohol appears to be the first few weeks after conception, before the mother-to-be realizes she is pregnant (Refs. 10 and 11). Also, 17% or 170 per thousand of the embryo/fetuses of chronic alcoholics develop FAS and die before birth (Ref. 15). FAS was first identified in 1973 in the United States where less than full-blown effects of the syndrome are now referred to as fetal alcohol effects (FAE) (Ref. 12).

2.3 Smoking

Smoking during pregnancy causes reduced birth weights in babies amounting to 5 to 9 ounces on the average. In addition, there is an increased risk of 5 infant deaths per thousand for mothers who smoke less than one pack per day and 10 infant deaths per thousand for mothers who smoke one or more packs per day (Ref. 13).

2.4 Miscellaneous

Numerous other risks affect the embryo/fetus, only a few of which are touched upon here. Most people are familiar with the drug thalidomide (a sedative given to some pregnant women), which causes children to be born with missing limbs, and the more recent use of the drug diethylstilbestrol (DES), a synthetic estrogen given to some women to treat menstrual disorders, which produced vaginal cancers in the daughters born to women who took the drug. Living at high altitudes also gives rise to an increase in the number of low-birth-weight children born, while an increase in Down's Syndrome (mongolism) occurs in children born to mothers who are over 35 years of age. The rapid growth in the use of ultrasound in recent years has sparked an ongoing investigation into the risks of using ultrasound for diagnostic procedures (Ref. 19).

APPENDIX B

PREGNANT WORKER'S GUIDE

POSSIBLE HEALTH RISKS TO CHILDREN OF WOMEN WHO ARE EXPOSED TO RADIATION DURING PREGNANCY

During pregnancy, you should be aware of things in your surroundings or in your style of life that could affect your unborn child. For those of you who work in or visit areas designated as Restricted Areas (where access is controlled to protect individuals from being exposed to radiation and radioactive materials), it is desirable that you understand the biological risks of radiation to your unborn child.

Everyone is exposed daily to various kinds of radiation: heat, light, ultraviolet, microwave, ionizing, and so on. For the purposes of this guide, only ionizing radiation (such as x-rays, gamma rays, neutrons, and other high-speed atomic particles) is considered. Actually, everything is radioactive and all human activities involve exposure to radiation. People are exposed to different amounts of natural "background" ionizing radiation depending on where they live. Radon gas in homes is a problem of growing concern. Background radiation comes from three sources:

	Average Annual Dose
Terrestrial - radiation from soil and rocks	50 millirem
Cosmic - radiation from outer space	50 millirem
Radioactivity normally found within the human body	25 millirem
	125 millirem*
Dosage range (geographic and other factors)	75 to 5,000 millirem

The first two of these sources expose the body from the outside, and the last one exposes it from the inside. The average person is thus exposed to a total dose of about 125 millirems per year from natural background radiation.

In addition to exposure from normal background radiation, medical procedures may contribute to the dose people receive. The following table lists the average doses received by the bone marrow (the blood-forming cells) from different medical applications.

X-Ray Procedure	Average Dose*
Normal chest examination	10 millirem
Normal dental examination	10 millirem
Rib cage examination	140 millirem
Gall bladder examination	170 millirem
Barium enema examination	500 millirem
Pelvic examination	600 millirem

*Variations by a factor of 2 (above and below) are not unusual.

*Radiation doses in this document are described in two different units. The rad is a measure of the amount of energy absorbed in a certain amount of material (100 ergs per gram). Equal amounts of energy absorbed from different types of radiation may lead to different biological effects. The rem is a unit that reflects the biological damage done to the body. The millirad and millirem refer to 1/1000 of a rad and a rem, respectively.

NRC POSITION

NRC regulations and guidance are based on the conservative assumption that any amount of radiation, no matter how small, can have a harmful effect on an adult, child, or unborn child. This assumption is said to be conservative because there are no data showing ill effects from small doses; the National Academy of Sciences recently expressed "uncertainty as to whether a dose of, say, 1 rad would have any effect at all." Although it is known that the unborn child is more sensitive to radiation than adults, particularly during certain stages of development, the NRC has not established a special dose limit for protection of the unborn child. Such a limit could result in job discrimination for women of child-bearing age and perhaps in the invasion of privacy (if pregnancy tests were required) if a separate regulatory dose limit were specified for the unborn child. Therefore, the NRC has taken the position that special protection of the unborn child should be *voluntary* and should be based on decisions made by workers and employers who are well informed about the risks involved.

For the NRC position to be effective, it is important that both the employee and the employer understand the risk to the unborn child from radiation received as a result of the occupational exposure of the mother. This document tries to explain the risk as clearly as possible and to compare it with other risks to the unborn child during pregnancy. It is hoped this will help pregnant employees balance the risk to the unborn child against the benefits of employment to decide if the risk is worth taking. This document also discusses methods of keeping the dose, and therefore the risk, to the unborn child as low as is reasonably achievable.

RADIATION DOSE LIMITS

The NRC's present limit on the radiation dose that can be received on the job is 1,250 millirems per quarter (3 months).* Working minors (those under 18) are limited to a dose equal to one-tenth that of adults, 125 millirems per quarter. (See § 20.101 of 10 CFR Part 20.)

Because of the sensitivity of the unborn child, the National Council on Radiation Protection and Measurements (NCRP) has recommended that the dose equivalent to the unborn child from occupational exposure of the expectant mother be limited to 500 millirems for the entire pregnancy (Ref. 2). The 1987 Presidential guidance (Ref. 1) specifies an effective dose equivalent limit of 500 millirems to the unborn child if the pregnancy has been declared by the mother; the guidance also recommends that substantial variations in the rate of exposure be avoided. The NRC (in § 20.208 of its proposed revision to Part 20) has proposed adoption of the above limits on dose and rate of exposure.

ADVICE FOR EMPLOYEE AND EMPLOYER

Although the risks to the unborn child are small under normal working conditions, it is still advisable to limit the radiation dose from occupational exposure to no more than 500 millirems for the total pregnancy. Employee and employer should work together to decide the best method for accomplishing this goal. Some methods that might be used include reducing the time spent in radiation areas, wearing some shielding over the abdominal area, and keeping an extra distance from radiation sources when possible. The employer or health physicist will be able to estimate the probable dose to the unborn child during the normal nine-month pregnancy period and to inform the employee of the amount. If the predicted dose exceeds 500 millirems, the employer and employer should work out schedules or procedures to limit the dose to the 500-millirem recommended limit.

It is important that the employee inform the employer of her condition as soon as she realizes she is pregnant if the dose to the unborn child is to be minimized.

INTERNAL HAZARDS

This document has been directed primarily toward a discussion of radiation doses received from sources outside the body. Workers should also be aware that there is a risk of radioactive material entering the body in workplaces where unsealed radioactive material is used. Nuclear medicine clinics, laboratories, and certain manufacturers use radioactive material in bulk form, often as a liquid or a gas. A list of the commonly used materials and safety precautions for each is beyond the scope of this document, but certain general precautions might include the following:

1. Do not smoke, eat, drink, or apply cosmetics around radioactive material.
2. Do not pipette solutions by mouth.
3. Use disposable gloves while handling radioactive material when feasible.
4. Wash hands after working around radioactive material.
5. Wear lab coats or other protective clothing whenever there is a possibility of spills.

Remember that the employer is required to have demonstrated that it will have safe procedures and practices before the NRC issues it a license to use radioactive material. Workers are urged to follow established procedures and consult the employer's radiation safety officer or health physicist whenever problems or questions arise.

*The limit is 3,000 millirems per quarter if the worker's occupational dose history is known and the average dose does not exceed 5,000 millirems per year.

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Reminder of Good Radionuclide Laboratory Safety Practices

1. Never pipette by mouth.
2. No smoking or eating permitted in the work area.
3. Gloves and laboratory coat are required when using radionuclides.
4. Prescribed personnel monitors must be worn.
5. Hands, shoes and clothing should be frequently monitored.
6. Work with radioactive materials in an approved hood or glove box, unless the safety of working on an open bench can be demonstrated.
7. Radionuclide work should be conducted in an impervious tray or pan, lined with absorbent paper.
8. Utilize shielding and distance whenever possible.
9. Dispose of liquid and solid radioactive waste in the approved containers provided.
10. Refrigerators containing radionuclides shall not be used for storing food.
11. Monitor radionuclide work areas at least once daily for contamination and make notation of this survey in laboratory records.
12. Thoroughly wash hands after manipulating radionuclides, before eating or smoking, and on completion of work.
13. Maintain records of receipt, use, transfer and disposal of radioactive materials.
14. Report accidental inhalation, ingestion, injury or spills to your supervisor and the Radiation Safety Office.
15. Review pertinent safety practices frequently, especially before using a new radionuclide.
16. Assure compliance with NIH Radiation Safety Guide and Title 10, Code of Federal Regulations, Parts 19 and 20.

UNITED STATES NUCLEAR REGULATORY COMMISSION
Washington, D.C. 20555

NOTICE TO EMPLOYEES

STANDARDS FOR PROTECTION AGAINST RADIATION (PART 20); NOTICES, INSTRUCTIONS AND REPORTS TO WORKERS; INSPECTIONS (PART 19); EMPLOYEE PROTECTION

WHAT IS THE NUCLEAR REGULATORY COMMISSION?

The Nuclear Regulatory Commission is an independent Federal regulatory agency responsible for licensing and inspecting nuclear power plants and other commercial uses of radioactive materials.

WHAT DOES THE NRC DO?

The NRC's primary responsibility is to ensure that workers and the public are protected from unnecessary or excessive exposure to radiation and that nuclear facilities, including power plants are constructed to high quality standards and operated in a safe manner. The NRC does this by establishing requirements in Title 10 of the Code of Federal Regulations (10 CFR) and in licenses issued to nuclear users.

WHAT RESPONSIBILITY DOES MY EMPLOYER HAVE?

Any company that conducts activities licensed by the NRC must comply with the NRC's requirements. If a company violates NRC requirements, it can be fined or have its license modified, suspended or revoked.

Your employer must tell you which NRC radiation requirements apply to your work and must post NRC Notices of Violation involving radiological working conditions.

WHAT IS MY RESPONSIBILITY?

For your own protection and the protection of your co-workers, you should know how NRC requirements relate to your work and should obey them. If you observe violations of the requirements, you should report them.

HOW DO I REPORT VIOLATIONS?

If you believe that violations of NRC rules or of the terms of the license have occurred, you should report them immediately to your supervisor. If you believe that adequate corrective action is not being taken, you may report this to an NRC inspector or to the nearest NRC Regional Office.

WHAT IF I WORK IN A RADIATION AREA?

If you work with radioactive materials or in a radiation controlled area, the amount of radiation exposure that you may legally receive is limited by NRC Regulations. The limits on your exposure are contained in Sections 20.101, 20.103, and 20.104 of Title 10 of the Code of Federal Regulations (10 CFR 20). While these are the maximum allowable limits, your employer should also keep your radiation exposure as far below those limits as is "reasonably achievable."

MAY I GET A RECORD OF MY RADIATION EXPOSURE?

Yes. Your employer is required to tell you in writing if you receive any radiation exposure above the limits set in the NRC regulations or your employer's license. In addition, if your job involves radiation, you may request from your employer a record of your annual radiation exposure and a written report of your total exposure when you leave your job.

HOW ARE VIOLATIONS OF NRC REQUIREMENTS IDENTIFIED?

NRC conducts regional inspections at licensed facilities to assure compliance with NRC requirements. In addition, your employer and his contractors conduct their own inspections to assure compliance. All inspectors are protected by Federal law. Interference with them may result in criminal prosecution by a Federal official.

MAY I TALK WITH AN NRC INSPECTOR?

Yes. Your employer may not prevent you from talking with an NRC inspector and you may talk privately with an inspector and request that your identity remain confidential.

MAY I REQUEST AN INSPECTION?

If you believe that your employer has not corrected violations involving radiological working conditions, you may request an inspection. Your request should be addressed to the nearest NRC Regional Office and must describe the alleged violation in detail. It must be signed by you or your representative.

HOW DO I CONTACT THE NRC?

Notify an NRC inspector on site or call the nearest NRC Regional Office listed. NRC inspectors want to talk to you. If you are worried about radiation safety or other aspects of licensed activities, such as the posting or construction of repositories at your plant.

CAN I BE FIRED FOR TALKING TO THE NRC?

No. Federal law prohibits an employer from firing or otherwise discriminating against a worker for bringing safety concerns to the attention of the NRC. You may not be fired or discriminated against because you:

- ask the NRC to enforce its rules against your employer;
- testify in an NRC proceeding;
- provide information to the NRC about violations of requirements;
- are about to ask for or testify, help, or take part in an NRC proceeding.

WHAT FORMS OF DISCRIMINATION ARE PROHIBITED?

No employer may fire you or discriminate against you with respect to pay, benefits, or working conditions because you help the NRC.

HOW AM I PROTECTED FROM DISCRIMINATION?

If you believe that you have been discriminated against for bringing safety concerns to the NRC, you may file a complaint with the U.S. Department of Labor. Your complaint must describe the firing or discrimination and must be filed within 30 days of the discrimination.

Send complaints to:

Office of the Administrator
Wage and Hour Division
Employment Standards Administration
U.S. Department of Labor
Room 6-3502
200 Constitution Avenue, N.W.
Washington, D.C. 20210

or any local office of the Department of Labor, Wage and Hour Division. Check your telephone directory under U.S. Government, Labor.

WHAT CAN THE LABOR DEPARTMENT DO?

The Department of Labor will notify the employer that a complaint has been filed and will investigate the case.

If the Department of Labor finds that your employer has unlawfully discriminated against you, it may order you to be reinstated, receive back pay, or be compensated for any injury suffered as a result of the discrimination.

WHAT WILL THE NRC DO?

The NRC may assist the Department of Labor in its investigation. NRC may conduct its own investigation where necessary to determine whether unlawful discrimination has occurred and the free flow of information to the Commission. Also, if the NRC or Department of Labor finds that unlawful discrimination has occurred, the NRC may issue a Notice of Violation to your employer, impose a fine, or suspend, modify, or revoke your employer's NRC license.

UNITED STATES NUCLEAR REGULATORY COMMISSION REGIONAL OFFICE LOCATIONS

A representative of the Nuclear Regulatory Commission can be contacted at the following addresses and telephone numbers. The Regional Office will accept collect telephone calls from employees who wish to register complaints or concerns about radiological working conditions or other matters regarding compliance with Commission rules and regulations.

Regional Offices

REGION	ADDRESS	TELEPHONE
I	U.S. Nuclear Regulatory Commission Region I 475 Allendale Road King of Prussia, PA 19406	215 337 5000
II	U.S. Nuclear Regulatory Commission Region II 101 Marietta St., N.W. Atlanta, GA 30323	404 331 4503
III	U.S. Nuclear Regulatory Commission Region III 799 Roosevelt Road Glen Ellyn, IL 60137	312 790 5500
IV	U.S. Nuclear Regulatory Commission Region IV 611 Ryan Plaza Dr., Suite 1000 Arlington, TX 76011	817 860 8100
V	U.S. Nuclear Regulatory Commission Region V 1450 Maria Lane, Suite 210 Walnut Creek, CA 94596	415 943 3700

NRC FORM 3
(5-89)

BETWEEN:

LICENSE FEE MANAGEMENT BRANCH, ARM
AND
REGIONAL LICENSING SECTIONS

(FOR LFMS USE)
INFORMATION FROM LTS

PROGRAM CODE: 03511
STATUS CODE: 7
FEE CATEGORY: 3K 3F
EXP. DATE: 1-911031
FEE COMMENTS: V
DECOM FIN ASSUR REQD: N

LICENSE FEE TRANSMITTAL

A. REGION

1. APPLICATION ATTACHED
APPLICANT/LICENSEE: HEALTH & HUMAN SERVICES, DEPT. OF
RECEIVED DATE: 910926
DOCKET NO: 3017872
CONTROL NO.: 115574
LICENSE NO.: 19-00296-20
ACTION TYPE: RENEWAL

2. FEE ATTACHED
AMOUNT: #150.----
CHECK NO.: ----0----

3. COMMENTS

SIGNED Rebecca A. Brown
DATE 10/8/91

B. LICENSE FEE MANAGEMENT BRANCH (CHECK WHEN MILESTONE 03 IS ENTERED /__/)

1. FEE CATEGORY AND AMOUNT: ----------

2. CORRECT FEE PAID. APPLICATION MAY BE PROCESSED FOR:
AMENDMENT ----------
RENEWAL ----------
LICENSE ----------

3. OTHER ----------

SIGNED ----------
DATE ----------