Attachment 2
National Aeronautics and Space
Administration
Lyndon B. Johnson Space Center
Reference: NRC-2
August 1, 1981

JSCM 1860B
SUPERSEDES JSCM 1860A
(MARCH 1976)

RADIOLOGICAL HEALTH MANUAL

National Aeronautics and Space Administration

LYNDON B. JOHNSON SPACE CENTER

Houston, Texas

JANUARY 1978

FOREWORD

This manual is issued to provide guidance to personnel, both NASA and contractor, in the procurement and safe handling of radioactive materials or radiation-producing equipment while being used or stored at the Johnson Space Center (JSC). Suggestions for changes and improvements to this manual should be submitted to the JSC Radiation Safety Committee for consideration via the Biomedical Applications Branch, SD5.

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Director of Space and Life Sciences

JSCM 1860B (January 1978)
Supersedes JSCM 1860A
(March 1976)

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PART 1

GENERAL DESCRIPTION

1.1 PURPOSE

This manual describes the policy, organization, procedures, and requirements for the radiological health and safety activity of the Johnson Space Center (JSC).

1.2 SCOPE

This manual includes organization, training, and responsibilities for radiological health and safety at JSC. It defines JSC procedures and requirements for procurements, use, handling, storage, shipment, and disposal of sources of ionizing radiation, as well as personnel monitoring and emergency procedures. It also indicates reference documents from which more detailed information may be obtained when necessary.

1.3 JSC POLICY (See Appendix A, JSCI 1860.4)

It is the policy of JSC to: (1) exercise centralized control over operations involving use of radioactive materials and radiation-producing equipment; (2) assure that exposure of personnel to ionizing radiation from radioactive materials or radiation-producing equipment is kept to a minimum; (3) assure that compliance with applicable federal, state and local regulations is maintained; (4) hold each supervisor responsible for training those employees who are to use ionizing radiation and to see that all work is in compliance with applicable regulations.

1.4 APPLICABILITY (See Appendix A, JSCI 1860.4)

The procedures and radiation protection practices as set forth in this manual apply to all organizational elements of JSC and to all contractors working in facilities under the administrative control of JSC. It should be noted that regulations quoted are Federal statutes imposed on NASA under terms of its licenses with the Nuclear Regulatory Commission (NRC, formerly Atomic Energy Commission), and applicable regulations promulgated by Occupational Health and Safety Administration (OSHA), Food and Drug Administration (FDA) and the Department of Transportation (DOT). Questions concerning details of current regulations or the applicability of regulations should be referred to the JSC Biomedical Applications Branch, SD5.

1.5 REVISION OF MANUAL

Approved revisions to this manual will be developed by and for approval of the JSC Radiation Safety Committee. Specific changes will be numbered and transmitted by the Biomedical Applications Branch, SD5, and will consist of a change checklist, and the new pages to be inserted into the document.

PART 2

JSC ORGANIZATION FOR RADIOLOGICAL HEALTH

The Director of Space and Life Sciences, with authority granted by the Director of JSC, has appointed the Radiation Safety Committee and the Medical Isotopes Operations Subcommittee to assure control of radiation and to assure compliance with federal regulations governing the use of ionizing radiation. Policies of the Radiation Safety Committee are carried out in day-to-day activities by the line supervisor of radiation use personnel. A Radiological Safety Officer has been designated in a contractor team of professional health physicists which assists the radiation user by providing administrative and technical guidance in radiological health.

The Radiation Constraints Panel established by the Director of JSC is responsible for coordinating all operational aspects of radiation pertaining to manned spaceflights managed by JSC.

The overall organization chart for Radiological Safety at JSC is outlined in Figure 1 of this Part.

2.1 RADIATION SAFETY COMMITTEE

The Radiation Safety Committee implements the functions and responsibilities outlined below: (Appendix A, JSCI 1860.1)

a. Coordinates and controls the use of ionizing radiation.

b. Reviews and approves all JSC radiological health policies and procedures.

c. Develops and coordinates materials incorporated in the JSC Radiological Health Manual.

d. Performs the functions defined by Title 10, Code of Federal Regulations, Part 33. (Appendix G, 10 CFR 33)

2.2 MEDICAL ISOTOPES OPERATIONS SUBCOMMITTEE

The Medical Isotopes Operations Subcommittee, by means of guidelines set forth in Appendix E of this manual, performs the functions and assumes the responsibilities outlined below. (Appendix A, JSCI 1860.2).

a. Reviews the training and experience in medical uses of radioactive material of physicians wishing to use radiopharmaceuticals, and approves those physicians who are to use or directly supervise the human use of radioactive material.

b. Reviews, from the standpoint of radiological health and safety, and approves or disapproves requests for use of radioactive material or radiation-producing equipment in or on humans.

c. Evaluates and coordinates the use of isotopes for medical purposes under a private practice or organizational license in or for JSC programs.

2.3 RADIOLOGICAL HEALTH OFFICER

The Radiological Health Officer is responsible for the operation and supervision of the local radiological health activity and is a member of the Radiation Safety Committee, the Medical Isotopes Operations Subcommittee and the Radiation Constraints Panel. Specifically, the functions are:

a. Formulates radiation safety criteria for review by the JSC Radiation Safety Committee.

b. Assists JSC line supervisors in implementing radiation safety rules and procedures as promulgated by the Radiological Safety Officer (See Part 2, Section 2.4) and the JSC Radiation Safety Committee.

c. Reviews and provides consulting services on the radiation safety aspect of all proposed facilities and space system designs which involve radioactive material or radiation sources.

d. Coordinates with NRC on matters concerning the regulatory and reporting functions.

e. Evaluates technical reviews of all proposed uses of facilities for radioactive material and radiation machines to assure conformity with applicable regulations, standards and good practice. Recommends to JSC Radiation Safety Committee approval or disapproval of such facilities.

f. Exercises general surveillance over all uses of radiation at JSC including on-site contractor activities to assure radiation use in conformity with safe practice, pertinent regulations and with provisions approved by the Radiation Safety Committee for specific Radiation Use Authorizations.

2.4 RADIOLOGICAL SAFETY OFFICER (RSO)

The Radiological Safety Officer is responsible to the Radiological Health Officer and is an ex-officio member of the Radiation Safety Committee and the Medical Isotopes Operations Subcommittee. The duties and responsibilities of the Radiological Safety Officer are as outlined below: (Appendix A, JSCA 75-62).

a. Assumes control and initiates corrective action in radiological emergencies.

b. Coordinates with NRC on matters concerning the regulatory and reporting functions through the Radiological Health Officer.

c. Prepares incident and overexposure reports required by the NRC and other agencies.

d. Performs technical reviews of all proposed uses of facilities for radioactive material and radiation machines to assure conformity with applicable regulations, standards and good practice.

e. Assists line supervisors as primary contact on a day-to-day basis for matters related to radiation safety.

f. Assures that the disposal of radioactive waste is safe and complies with Federal, State, local government and JSC requirements.

g. Operates the Health Physics Laboratory, the Isotope Storage Facility and the Radiation Chemistry Laboratory.

h. Provides training and indoctrination of personnel in radiation safety.

i. Reviews all purchase requests for radiation sources and irradiation services for compatibility with approved programs and licensing requirements.

j. Performs radiation protection surveys and radiation safety evaluations including leak tests required by NRC license.

k. Provides radiation instrument calibration services and controls the instrument calibration facility.

l. Provides personnel dosimetry for ground operations. Interprets and reports results and maintains permanent dosimetry records.

m. Performs radio-assays as required.

n. Maintains a central inventory of all radiation sources and provides a repository for those that are not in use.

o. Inspects and maintains records of all receipts and shipments of radiation sources.

2.5 RADIATION CONSTRAINTS PANEL

The Radiation Constraints Panel is responsible for coordinating all operational aspects of radiation pertaining to manned spaceflights managed by JSC. The panel will perform the following specific functions: (Appendix A, JSCI 1660.5).

a. Review all operational aspects of radiation including coordination of exposure limits, mission objectives, crew and operational considerations and program requirements to arrive at a consolidated Center position.

b. Coordinate and evaluate all requirements for all operational radiation instrumentation, and recommend appropriate action to the cognizant program office.

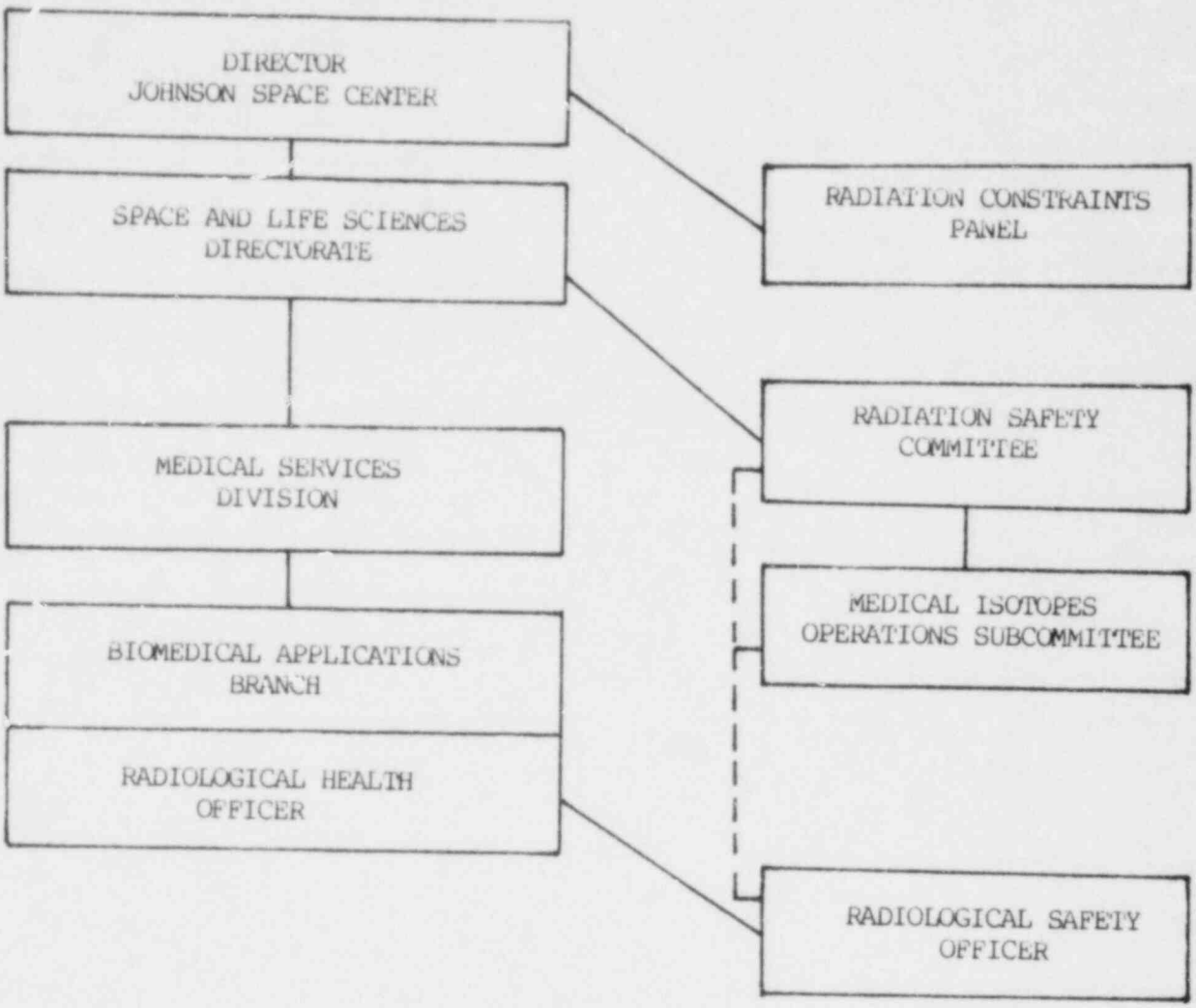
c. Review all missions for radiation constraints, nominal exposure, trade-offs, contingencies, procedures, mission rules, and other mission considerations.

d. Review all radiation support for each mission, including onboard instrumentation, the Mission Control Center, radiation network, other Government agencies, and additional support appropriate to the mission.

e. Collect, review, and publish for each mission a detailed listing of all radiation sources on the vehicles being flown.

The Radiation Constraints Panel will determine the requirements and necessary support for each program and provide recommendations to the appropriate program manager for implementation.

Figure 1



RADIOLOGICAL HEALTH WITHIN THE JSC ORGANIZATION

PART 3

ROUTINE PROCEDURES AND REQUIREMENTS

3.1 USER

The user or operator of any ionizing radiation source shall have adequate training and experience, to receive, use and have custody of specific regulated sources of ionizing radiation, as determined by the Radiation Safety Committee.

Supervisors of radiation users or operators shall be responsible for insuring compliance with the provisions of this manual.

3.2 RADIATION USE AUTHORIZATIONS

In order for the Radiation Safety Committee to evaluate potential hazards associated with the use of a regulated radiation source, a Radioactive Material Use Authorization (JSC Form 1942) or Radiation Machine Use Authorization (JSC Form 1943) shall be submitted by the proposed user of the radiation source. The requested use authorization shall contain a description of the operating procedures, which include detailed safety precautions, the use location, identities and qualifications of the users and their supervisors. Prior to, or concurrent with the preparation of the radiation use request, the radiological health staff shall perform a radiological safety analysis, or initial radiation protection survey, and a report of these findings shall be submitted to the Radiation Safety Committee, along with the radiation use request. (See Appendix C).

The Radiation Safety Committee will review the originator's proposal, the user's qualifications and recommendations made by the Radiological Safety Officer or Radiological Health Officer. If satisfied that the proper precautions are to be taken, they will approve the request, binding the users to all statements represented. If additional recommendations are considered appropriate by the Committee, a written condition shall be added to the authorization applicable to each recommendation.

Modifications to approved authorizations shall be submitted on the JSC Form 1942 or Form 1943 and follow the same processing as the original request. In addition to materials presented by the originator, for consideration by the Committee, previous survey results and hazard evaluations shall be given primary importance for approval of renewed or modified use authorizations. Information contained in previous submittals to the JSC Radiation Safety Committee may be incorporated by reference provided references are clear and specific.

3.2.1 RENEWAL OR TERMINATION OF RADIATION USE AUTHORIZATIONS

Approved Use Authorizations terminate after the date recorded on the approved authorization. The following procedures shall be followed to insure proper authorizations on control sources of ionizing radiation:

a. Thirty (30) days prior to expiration date of a Radiation Use Authorization, a written notice shall be submitted to the Radiation Use Authorization originator and originator's supervisor and/or technical manager if originator is a contractor, with advisement of authorization expiration and subsequent consequence.

b. If a Radiation Use Authorization renewal has not been applied for within seven (7) days of the expiration date, and the operation is to continue, a second notice shall be submitted with an additional copy of the expiration notice to be transmitted to the functional Director.

c. If a Radiation Use Authorization renewal has not been applied for by expiration date, the Radiation Safety Committee Chairman shall advise the functional Director of the circumstances.

d. The first working day following expiration date of an approved Radiation Use Authorization, the source of ionizing radiation shall be placed in controlled storage or secured against unauthorized use pending appropriate action.

3.2.2 SPECIAL REQUIREMENTS FOR OFF-SITE RADIATION USE AUTHORIZATIONS

Prior to approving a Radiation Use Authorization for an organizational element of JSC in which the material or equipment will be used at a temporary-job-site (a facility not under the administrative control of JSC) the following requirements shall be satisfied.

a. Written authorization shall be obtained from the administration of the facility where use of radioactive materials is proposed. If the facility or institution holds a by-product license from the Nuclear Regulatory Commission or an agreement state, the use of byproduct materials should be concurred in by the local Radiation Safety Officer and/or the Radiation Safety Committee.

b. To assure minimal radiation exposure to individuals and confirm no residual radioactive contamination remains in the facility, an individual shall be named with adequate training and experience in radiological health activities to select suitable instrumentation and perform monitoring tasks as determined necessary by the JSC Radiation Safety Committee.

c. Procedures and arrangements for disposal, to handle radioactive waste generated at the temporary job site, shall be formally specified and approved by the JSC Radiation Safety Committee. The preferred waste disposal method shall be by direct transfer to Nuclear Regulatory Commission or agreement state licensee authorized to perform collection and/or disposal of radioactive waste.

d. Duration of radiation use under these procedures shall be limited to 30 days inclusive. When a demonstrated need for a longer use period exists, the request for Radiation Use Authorization shall be submitted at least 60 days in advance of need date to allow time for the JSC Radiation Safety Committee to secure the necessary approval from the Nuclear Regulatory Commission.

All records of radiation surveys, personnel monitoring and radioactive material transfers shall be maintained by the use supervisor and submitted to the Biomedical Applications Branch, SD5, at the completion of the authorized use. Any incidents involving individuals overexposed, lost sources or contamination problems shall be reported immediately to the Radiological Safety Officer at JSC, in accordance with Part 4 of this manual.

3.2.3 INTERIM APPROVALS

When an immediate use of ionizing radiation is determined necessary, the Radiological Safety Officer may temporarily modify the following previously approved authorizations with verbal concurrence from the Radiation Safety Committee Chairman:

a. Extend an expiration date of a Radiation Use Authorization for a period not exceeding 60 days.

b. Add specific users provided that individuals have met the standards of training and experience established by the Radiation Safety Committee and the approved supervisor has not changed.

c. Add to the isotopes named on an approved authorization provided the isotopes added will not change the kinds of radiation emissions previously approved and the hazard from absorption into the body as defined in National Bureau of Standards Handbook 48 does not increase.

The Radiation Safety Committee (RSC) will evaluate these temporary modifications, and if satisfied that the Radiological Safety Officer's action was proper, will ratify the actions at the next Radiation Safety Committee meeting.

Approvals may be withdrawn at any time if safety violations occur or use of a regulated source is found not to be in compliance with conditions of the approved use.

3.3 RADIATION SURVEYS

a. Initial Radiation Surveys - Prior to the use of radioactive material or the operation of radiation-producing machines, an initial radiation survey shall be performed by the radiological health staff. Based on this survey, general procedures for safe handling and use will be recommended while leaving as much latitude as is safe and feasible.

b. Periodic Radiation Surveys - The radiological health staff will schedule periodic inspections and radiation surveys of each facility where radiation is being used. Any unsafe practices will be called to the attention of the Radiological Safety Officer who may revoke the Radiation Use Authorization with concurrence from the Radiological Health Officer. Revocation of Use Authorization will require immediate notification of available members of the Radiation Safety Committee and appropriate NASA management.

The results of initial radiation surveys and periodic radiation surveys shall be presented to the JSC Radiation Safety Committee to allow a complete review and evaluation of existing and proposed uses of ionizing radiation.

c. Survey Instruments - Appendix D contains a list of radiation detection instruments available through the Biomedical Applications Branch, SD5, for surveys and area monitoring at JSC facilities.

3.4 TRAINING AND EDUCATION

Instruction of personnel is of great importance to the success of radiation protection activity. As a minimum, and prior to working with ionizing radiation, individuals must have had either radiation experience and/or training covering at least the following points:

a. General description of radiation and its hazards.

b. Basic principles of radiation safety.

c. Radiation safety procedures relevant to duties associated with employment.

d. JSC policies and appropriate Federal regulations.

e. Emergency procedures.

Periodic instructions will be carried out on-the-job by radiological health staff. Emphasis will be placed on updating operating methods and emergency procedures.

If, due to the nature of work to be done, personnel are subject to unusual hazard, they may be required to have additional training as determined by the Radiation Safety Committee.

3.5 PROCUREMENT, STORAGE AND TRANSFER OF RADIATION SOURCES

a. Procurement - Radiation sources to be used in JSC controlled facilities shall not be procured without approval by the Biomedical Applications Branch, SD5. The originator of a procurement document shall provide a detailed description of the proposed use of radioactive materials and use location to the Biomedical Applications Branch, SD5, which will authorize further procurement processing.

Procurement Division responsibilities shall be:

(1) To coordinate with the Purchase Request initiator whenever it is believed that a controlled radiation source will be involved in the proposed procurement and approval of the Biomedical Applications Branch, SD5, is not indicated.

(2) To include in contracts and purchase orders for radioactive materials an instruction to the vendor to place on the shipping label the words:

"Notify Radiological Safety Officer Upon Arrival."

b. Receipt - The Radiological Safety Officer shall be notified of all arrivals of sources of radiation at JSC and shall transfer the materials to Building 263 for documentation, inspection and leak testing if applicable. For purposes of documentation, the originator or the shipment is requested to furnish a completed JSC Form 1625 in addition to other relevant shipping documents. A copy of this form will be returned to the shipment originator. (See Appendix C).

c. Storage - All radioactive materials not covered by a current authorization approved by the Radiation Safety Committee shall be stored in Building 263A. Exceptions shall be only those quantities of radioactive material in less than general licensed amounts, specified in 10 CFR 31, or for flight items that can be properly controlled in the bonded storage locations. All storage areas for radioactive materials shall be so constructed that only authorized users have access to the material.

d. Shipping - All sources of radiation once documented by the radiological health staff and located in a particular facility shall not be tranferred to the accountability of another organization, or transferred from one location to another within JSC without prior approval of the Radiological Safety Officer in addition to action required for property control procedures.

Off-site shipments require documentation and completion of JSC Form 1625, which shall be included with other relevant shipping documents. Each shipment shall be made in accordance with the applicable Federal, state and local transportation regulations. These regulations are referenced in Appendix F in this manual.

e. All shipments of radioactive material shall be under the auspicies of the Transportation Branch, JF7, when the shipment is sponsored by or shipped in connection with a JSC sponsored project.

3.6 AREA DESIGNATIONS

The following area designations shall apply for purposes of radiation control at JSC:

a. Controlled Area - Any area to which access is controlled for purposes of protection of individuals from exposure to radiation and radioactive material. The term "controlled" is meant to be synonymous with the term, "restricted" as used in the NRC Regulations.

b. Radiation Area - Any area, accessible to personnel, in which there exists radiation at such levels that a major portion of the body could receive in any one hour a dose in excess of 2 millirem.

c. High Radiation Area - Any area, accessible to personnel, in which there exists radiation at such levels that a major portion of the body could receive, in any one hour, a dose in excess of 100 millirem.

d. Airborne Radioactivity Area - Any room, enclosure, or operating area in which airborne radioactive materials exist in concentrations in excess of the amounts specified in Appendix B, Table I, Column 1, of 10 CFR 20; or any room, enclosure, or area in which 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 1, Column 1, of 10 CFR 20.

e. Uncontrolled Area - Any area to which access is not controlled for purposes of protection of individuals from exposure to radiation and radioactive materials. The term "uncontrolled" is meant to be synonymous with the term "unrestricted" as used in the NRC Regulations.

f. Contamination Area - Any area, accessible to personnel, from which 10 disintegrations per minute (dpm) of alpha particles or 200 dpm of beta particles or gamma photons may be removed from a 100 centimeter square area.

3.7 RADIATION DOSE LIMITS

Radiation dose limits at JSC are based upon limits specified by the NRC in 10 CFR 20. It should be recognized that the JSC limits are established as maximum values and, in all cases, personnel exposure should be maintained as far below the limits specified in this part as practical. A particular effort should be made to keep the radiation exposure of an embryo or fetus to the very lowest practicable level during the entire gestation period as recommended by the National Council on Radiation Protection and Measurements. (See Appendix G, NRC Regulatory Guide 8.13).

a. Dose Limits for Controlled Areas - Personnel shall not be exposed routinely to radiation or radioactive material in such a manner that the following limits are exceeded:

	Rem/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	7.50

In exceptional cases an individual may be permitted to receive a quarterly, whole body dose greater than 1.25 rem provided:

(1) During any calendar quarter the dose to the whole body shall not exceed 3 rem; 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) rem where N equals the individual's age in years at his last birthday; and

(3) The individual's prior accumulated exposure has been determined.

b. Dose Limits for Minors - An individual under the age of 18 years shall not be permitted to enter or be employed in controlled areas such that he will receive doses of radiation in amounts exceeding 10 percent of the limits in 3.7, a. Exposures shall be averaged over periods not to exceed one calendar quarter.

c. Dose Limits in Uncontrolled Areas - Radiation dose limits in uncontrolled areas shall be such that an individual will not receive a dose to the whole body in excess of 0.5 rem in any calendar year. Furthermore, radiation levels shall be such that if an individual was continuously present in the area, he would not receive a dose in excess of 100 millirem in any seven days.

3.8 AIRBORNE CONCENTRATION LIMITS

Airborne concentrations of radioactive materials to which personnel at JSC may be exposed are also based upon limits specified by the NRC in 10 CFR 20. Again, the JSC limits are established as maximum values, and in all cases airborne concentrations should be maintained at the lowest practical level.

a. Controlled Areas - With no allowance made for protective clothing or equipment, no personnel shall be exposed to airborne radioactive material in average concentrations in excess of the limits specified in Appendix B, Table I of 10 CFR 20. These limits are based upon an exposure to these concentrations for forty hours in any period of seven consecutive days. For exposure times, other than forty hours, the airborne concentration limits may be increased or decreased proportionately.

b. Minors - An individual under the age of 18 years shall not be exposed to airborne radioactive material in an average concentration in excess of the limits specified in Appendix B, Table 2 of 10 CFR 20. Concentrations may be averaged over periods not greater than one week.

c. Uncontrolled Areas - No personnel in uncontrolled areas shall be exposed to airborne radioactive material in concentrations in excess of the limits specified in Appendix B, Table 2, of 10 CFR 20. Concentrations may be averaged over a period not greater than one year.

3.9 PERSONNEL MONITORING

a. Personnel monitoring is required in any area where there is a probability that an individual may receive a radiation dose in excess of 25 percent of the limits in Part 3, Section 3.7a.

b. The details of the monitoring procedure shall be determined in each case by the Radiological Safety Officer in consultation with the Radiation Use Supervisor and with consideration of the dose limits. (See Part 3, Section 3.7).

c. Personnel monitoring procedures shall include, as a minimum, the wearing of film badges and/or pocket dosimeters. Film badges shall be changed for processing on or about the first working day of each month. Personnel monitoring devices shall be available from the Radiological Safety Officer. When needed, the appropriate radioassay service shall be furnished.

d. The Radiological Safety Officer shall maintain a permanent record of all personnel dosimetry reports. If a report indicates an overexposure, an investigation shall be initiated to determine cause and to suggest remedial action. The overexposure shall be reported to the NRC in compliance with 10 CFR 19.

e. Individuals determined to require radiation monitoring shall be advised annually of the worker's exposure to radiation or radioactive material as shown in records maintained by JSC.

3.10 POSTING AND LABELING

The posting and labeling requirements for JSC are based on the regulations in 10 CFR 19 and 10 CFR 20. The radiation symbols prescribed by this section shall be the conventional magenta or purple three-bladed design on a yellow background. Any additional information that may minimize exposure to radiation or to radioactive material shall be on or near signs and labels. Posting and labeling requirements are as follows:

a. Radiation Area - Each radiation area shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words:

CAUTION RADIATION AREA

b. High Radiation Area - Each high radiation area shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words:

CAUTION HIGH RADIATION AREA

All high radiation areas established for a period of 31 days or more, shall be 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 millirem in one hour upon entry into the area or shall energize a conspicuous, visible or audible alarm signal in such a manner that the individual entering and the supervisor of the operation are made aware of the entry.

c. Airborne Radioactivity Area - Each airborne radioactivity area shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words:

CAUTION AIRBORNE RADIOACTIVITY AREA

d. Storage Area - In addition to the above, each area in which radioactive 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 10 CFR 20, or which contains natural uranium or thorium in an amount exceeding 100-times the quantity specified in Appendix C of 10 CFR 20, shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words:

CAUTION RADIOACTIVE MATERIAL(S)

e. Operating Procedures and General Information - Areas in which individuals are employed in activities covered by the JSC Radiological Health Manual shall be posted with the following in such a manner to be readily observable to individuals on their way to or from their place of employment, or kept in a suitable place so that they are available for examination upon request:

(1) A current copy of 10 CFR 19.

(2) A current copy of 10 CFR 20.

(3) A current copy of 29 CFR 1910.96.

(4) A copy of the NRC License and document references therein.

(5) A copy of JSCM 1860A Radiological Health Manual.

(6) Notice of cited violations of appropriate Federal regulations and the resulting JSC actions.

In addition to the above, Form NRC-3, "Notice to Employees," must be posted in such a manner to be readily observable in areas utilizing radioactive materials.

f. Containers

(1) Each container of radioactive material shall bear a durable, clearly visible label identifying the radioactive contents as to radionuclide, quantity, and date of assay.

(2) The label shall bear the radiation symbol and the words:

CAUTION RADIOACTIVE MATERIAL(S)

g. Radiation-producing Machines or Equipment - X-ray machines, X-ray diffraction units, electron microscopes, and other similar equipment shall bear a durable, clearly visible label bearing the radiation caution symbol and the words:

CAUTION

THIS MACHINE PRODUCES X-RADIATION WHEN ENERGIZED

h. Exemptions to Posting and Labeling Requirements - Exemptions to posting and labeling requirements at JSC shall be approved by the Radiological Safety Officer and shall be limited to the following:

(1) An area is not required to be posted with a 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 (5) millirem per hour.

(2) Areas containing radioactive materials for less than eight hours do not require signs provided the materials are constantly attended during such periods by an individual who shall take precautions necessary to prevent a radiation exposure to any individual in excess of JSC limits.

(3) Areas are not required to be posted with signs because of the presence of radioactive materials packaged and labeled in accordance with applicable transportation regulations.

(4) Containers that do not contain materials in quantities greater than amounts specified in Appendix C of 10 CFR 20.

(5) Containers containing only natural uranium or thorium in quantities no greater than 10 times amounts specified in Appendix C of 10 CFR 20.

(6) Containers that do not contain licensed materials in concentrations greater than amounts specified in Appendix B, Table 1, Column 2 of 10 CFR 20.

(7) Containers when they are attended by an individual who shall take precautions necessary to prevent the radiation exposure to any individual in excess of the JSC limits.

(8) Containers which are accessible only to individuals authorized to use them, or to work in the vicinity, provided the contents are identified to such individuals by a readily available written record.

(9) Containers when they are in transport and packaged and labeled in accordance with applicable transportation regulations.

3.11 LEAK TESTS

a. Each sealed source containing byproduct material, other than Hydrogen 3 and devices under general license as defined in 10 CFR 31, with a half-life greater than thirty (30) days and in any form other than gas shall be tested for leakage and/or contamination at intervals not to exceed six (6) months. In the absence of a certificate from a transferor indicating that a test has been made within six (6) months prior to the transfer, the sealed source shall not be put into use until tested.

b. Notwithstanding the periodic leak test required by the preceding paragraph, any licensed sealed source containing byproduct material is exempted from periodic leak tests provided the quantity of byproduct material contained in the source does not exceed ten times the quantity specified for the byproduct material in Column II, Schedule A, Section 31.100, 10 CFR 31.

c. The periodic leak test required by this condition does not apply to sealed sources that are stored and not being used. The sources excepted from this test shall be tested for leakage prior to any use or transfer to another person unless they have been leak tested within six (6) months prior to the date of use or transfer.

d. The test shall be capable of detecting the presence of 0.005 microcurie of radioactive material on the test sample. The test sample shall be taken from the sealed source or from the surfaces of the device in which the sealed source is permanently mounted or stored on which one might expect contamination to accumulate. Records of leak tests results shall be kept in units of microcuries and maintained for inspection by the U. S. Nuclear Regulatory Commission.

e. If the test reveals the presence of 0.005 microcurie or more of removable contamination, the Radiological Safety Officer shall immediately withdraw the sealed source from use and shall cause it to be decontaminated and repaired or to be disposed of in accordance with NRC regulations. A report shall be filed within five (5) days of the test with the office that is charged with Byproduct Material Licensing, U. S. Nuclear Regulatory Commission, Washington, D. C., 20545, describing the equipment involved, the test results, and the corrective action taken. A copy of such report shall also be sent to the Director, Region IV, Office of Inspection and Enforcement, NRC, 611 Ryan Plaza Drive, Suite 1000, Arlington, Texas 76012.

f. Tests for leakage and/or contamination shall be performed by the radiological health staff as authorized by the NRC to perform such services.

g. A list of systems that may be used to evaluate leak tests is found in Appendix D.

3.12 INSTRUMENT CALIBRATION

All radiation detection instruments shall be calibrated and records maintained by the Radiological Safety Officer.

a. Portable Survey Meters - Portable instruments shall be calibrated prior to issue, every three months while in use, and/or after any repair.

The calibration procedure requires exposure to known radiation fields with at least two points in each range checked. Generally, the calibration checks will be made in the regions of 10-30 percent and 70-90 percent of full scale. In the event it is not possible to obtain a calibration check for a particular range, the instrument will be considered uncalibrated for that range and will be so marked. Should all calibration check readings fall within ± ten (10) percent, no change will be made in instrument settings. When the calibration check shows the instrument response to exceed the above tolerance, a calibration adjustment will be made according to the manufacturer's specific procedures. If the instrument's response exceeds ± twenty (20) percent either because of rate or energy dependence and cannot be corrected by adjustment, suitable correction factor graphs or charts will be prepared and attached to the instrument.

b. Laboratory Counting Equipment - All radiation counting equipment shall be calibrated prior to use and shall be accomplished by use of comparison standards.

3.13 RADIOACTIVE WASTE DISPOSAL

Special waste receptacles shall be provided by the Radiological Safety Officer for the disposal of low level solid and liquid radioactive wastes. These receptacles shall be conspicuously marked with the radiation symbol and the words:

CONTAMINATED WASTES

CAUTION RADIOACTIVE MATERIALS

Separate receptacles shall be provided for low level solid and liquid wastes, and these wastes shall be strictly segregated. Concentrated stock solutions of radioactive materials, sealed sources and other high level materials shall not be disposed of in low level waste containers. The radiological health staff, upon request by the Radiation Use Supervisor, shall be responsible for disposal or removal and storage of such high level material.

The contents of the radioactive waste receptacles shall be collected by the radiological health staff periodically. The arrangements for ultimate disposal of all radioactive waste resulting from JSC operations shall be the responsibility of the Biomedical Applications Branch, SD5, in conjunction with property control personnel. Disposal of high level material is limited to an appropriate licensee of the NRC or one of its Agreement States who will conduct final disposal operations.

Records of all radioactive waste disposals shall be maintained by the Radiological Safety Officer.

3.14 LAUNCH AND RECOVERY OF RADIOACTIVE MATERIAL

a. Authorization of Launch - Byproduct material will be used in launched spacecraft when authorized by NASA Headquarters which assumes responsibility for coordination with other agencies to assure compatibility of the proposed use with national policies and objectives.

b. Preflight - Sealed radioactive sources aboard spacecraft will be leak tested at routine intervals prior to launch in accordance with applicable NRC licenses and NASA issuances.

c. Postflight Operations - Postflight Operations are planned for accomplishment by a NASA recovery team.

   (1) The recovery team shall make an initial radioactive material status check in accordance with approved postretrieval procedures.

   (2) Prior to movement and shipment of radioactive material, following spacecraft deactivation procedures, a confirmation check of the radioactive material status will be conducted by the recovery team.

(3) All postflight procedures related to radioactive material shall be reviewed and approved by the JSC Radiation Safety Committee.

d. Documentation - The following documentation is required for radioactive material launched into space:

(1) The Radiological Safety Officer at the launch site shall indicate all radioactive material launched into space by completing JSC Form 1625. When completed, this form shall be sent to the Radiological Safety Officer at JSC.

(2) The Transportation Officer assigned to the recovery team shall indicate all radioactive material recovered by completing JSC Form 1625, and forward same to the Radiological Safety Officer at JSC.

(3) The Program Office concerned shall submit written notification to the JSC Radiological Safety Officer of all radioactive material launched into space but not recovered, including the possible location of these items.

(4) The above information is maintained in a permanent file for examination by regulatory officials of the government.

PART 4

EMERGENCY PROCEDURES

4.1 GENERAL

Contamination is easily spread during an emergency situation such as a fire, explosion, accidental breakage of a container, or spilling. Radioactive materials can be spread very rapidly and easily by the air currents set up by a fire. They may also find their way into an air-conditioning system, or, if spilled on the floor, they may be tracked around by personnel. This contamination is undetectable except by the use of special radiation-detecting devices, such as the Geiger counter. Since it is extremely difficult to set up adequate detection controls in an emergency, preplanned emergency procedures are included in this manual. Personnel whose work involves the use of radioactive materials shall familiarize themselves with these procedures.

4.2 PROCEDURES AFTER SPILLAGE OF RADIOACTIVE MATERIAL

a. General Responsibilities - Immediately after the occurrence of a spill, the involved person must vacate all affected personnel to a safe area. He will then notify by telephone, or by the most rapid method of communication, the Radiological Safety Officer, and follow his instructions or those of his authorized representative.

b. Specific Precautions - Unless he has received different instructions from the Radiological Safety Officer, the person involved in the spillage shall proceed to:

(1) Prevent all non-emergency personnel from approaching the contaminated area, or from attempting to deal with the spillage.

(2) Close all windows and other openings such as ventilating grills.

(3) Close and lock all doors.

(4) If the spillage involves powdered or gaseous radioactive material, seal all doors, and other openings after closing. Suitable sealing materials usually handy are wide masking tape, adhesive tape, or heavy wrapping paper, clipped or pasted to the frames.

c. Rules Affecting Conduct of All Personnel

(1) No person shall enter the affected area until the radiological health staff has conducted a contamination survey and has pronounced the area safe to resume work.

(2) Unauthorized personnel shall not attempt to make a survey, or to clean up the spillage.

(3) Decontamination procedures shall ALWAYS be conducted under the supervision of the Radiological Safety Officer or of his authorized qualified delegate.

(4) Personnel shall be instructed to keep their movements in the contaminated area to a minimum, to avoid spreading the contaminant by tracking.

4.3 FIRES IN RADIATION AREAS

In case of fire in areas where radioactive materials are in use, every practical effort should be made by the user to replace the material in its shielded container. If this is not possible, it is the responsibility of the user to promptly notify the Fire Department and Radiological Safety Officer or his alternate.

Fire Department personnel should be knowledgeable of radiation hazards, and the Fire Department is encouraged to contact the Radiological Safety Officer for periodic instruction. The Fire Department shall be kept notified in writing of all locations of radioactive materials in amounts that may prove hazardous to Fire Department personnel either externally or internally or that may present a serious contamination problem. Upon call to one of these locations, the Fire Chief, in consultation with the Radiological Safety Officer, shall be responsible to see that proper procedures are implemented to minimize radiation exposure to personnel and spread of contamination.

4.4 LOST OR MISPLACED SOURCES OF RADIATION

Lost or misplaced sources of radiation should be reported immediately to the Radiological Safety Officer.

The Radiological Safety Officer shall immediately prepare all reports required after a theft or loss of licensed material. The Radiological Health Officer, Chairman, Radiation Safety Committee or Director, Space and Life Sciences will coordinate and transfer such reports to the NRC.

4.5 NOTIFICATION OF ACCIDENTS

a. A user or operator will report to the Radiological Safety Officer immediately any incident or accident involving radiation sources or malfunction of radiation producing equipment. The Radiological Safety Officer will promptly investigate any such report and advise NASA management of his findings.

b. The Radiological Safety Officer will assure that the NRC is notified immediately following an accident as described in 10 CFR 20, paragraph 20.403.

c. The Radiological Safety Officer shall submit a written report for transmission to NRC within 30 days following an overexposure to radiation levels and concentrations of radioactive material as described in 10 CFR 20, paragraph 20.405.

APPENDIX A

JSC ANNOUNCEMENTS AND INSTRUCTIONS

1. Radiological Protection Policy
   JSCI 1860.4

2. JSC Radiation Safety Committee
   JSCI 1860.1

3. Radiological Health Activity
   JSCA

4. Medical Isotopes Operations Subcommittee of the
   JSC Radiation Safety Committee
   JSCI 1860.2

5. Radiation Constraints Panel
   JSCI 1860.5

6. Control of Padioactive Materials and Radiation
   Producing Devices
   JSCA

JOHNSON SPACE CENTER MANAGEMENT INSTRUCTION

Lyndon B. Johnson Space Center

NASA

DATE	NO
1/31/78	JSCI 1860.4E
RESP ORG	DIST
SA	A-3

APPROVED

for S. A. Gibbs

Christopher C. Kraft, Jr.
Director

RADIOLOGICAL PROTECTION POLICY

1. PURPOSE. To set forth the policies and responsibilities for insuring proper radiation controls and compliance with Federal regulations governing the use of hazardous radiation.

2. APPLICABILITY. This Instruction applies to all organizational elements of JSC and to all contractors working under the administrative control of JSC.

3. POLICY. It is the policy of JSC to exercise centralized control over operating procedures that involve exposure to hazardous radiation to insure that such exposure is kept to a minimum. Centralized control will also insure compliance with Federal statutes.

*4. AUTHORITY. The Director of Space and Life Sciences is authorized to establish all policies, procedures, and controls on the use of ionizing radiation at JSC and/or on space missions involving this Center. This includes authority to secure licenses or permits required for such activities and, by redelegation of authority granted in NMD 1150.7B, authority to establish the JSC Radiation Safety Committee and any subcommittees thereof.

5. RESPONSIBILITY. Supervisors are responsible for insuring proper orientation and training of personnel whose jobs entail use of, or exposure to, ionizing radiation.

6. RESCISSION. JSCI 1860.4D, dated August 15, 1974.

*Denotes change

JOHNSON SPACE CENTER MANAGEMENT INSTRUCTION

Lyndon B. Johnson Space Center

NASA

DATE	NO.
1/31/78	JSCI 1860.1E
REF. CIRC.	DIST.
SA/NA	A-3

APPROVED

Richard S. Johnston
Director of Space
and Life Sciences

JSC RADIATION SAFETY COMMITTEE

1. PURPOSE. To establish a JSC Radiation Safety Committee.

2. ESTABLISHMENT. This committee is established to satisfy the requirements for byproduct material licensing under U.S. Nuclear Regulatory Commission Rules and Regulations, 10 CFR 33.13, and to ensure compliance with the Department of Labor, Occupational Safety and Health Standards, 29 CFR 1910.96. Its establishment is necessary in the public interest in accordance with Federal regulatory matters.

3. FUNCTIONS. The JSC Radiation Safety Committee will:

a. Coordinate and control uses of ionizing radiation.

b. Review and approve JSC radiological health policies and procedures.

c. Develop and coordinate material for JSCM 1860, "Radiological Health Manual."

d. Perform the functions defined by 10 CFR 33 (Title 10, Code of Federal Regulations, Part 33).

*4. COMPOSITION. Personnel serving on the committee will be persons experienced in radiation protection and selected from the various Center directorates having programmatic control and operational safety requirements. Members are listed in the Attachment.

5. MEETINGS

*a. Meetings shall be held at the call of the Chairman with an agenda furnished or approved by him. Meetings shall be conducted in accord with bylaws approved by the Director of Space and Life Sciences.

b. Minutes of the committee meetings shall, as a minimum, contain a record of persons present, a description of matters discussed, conclusions reached, and actions taken; and shall include copies of all reports received, issued, or approved by the committee.

*c. The committee will be guided by provisions of applicable Federal rules, regulations, and standards, pertinent to NASA and JSC issuances.

6. RECORDS AND STAFF SUPPORTING SERVICES

a. Records and files of the committee will be maintained by the Space and Life Sciences Directorate.

b. Staff and supporting services will be provided by the Space and Life Sciences Directorate.

c. Any other standing committee created for radiological health related purposes will be constituted as a subcommittee of the JSC Radiation Safety Committee. Such subcommittees may be comprised of members (including consultants) not appointed to the JSC Radiation Safety Committee.

7. DURATION. The committee will function until this Instruction is rescinded.

8. RESCISSION. JSCI 1860.1D, dated 7/31/75.

*Denotes change

1/31/78

Attachment to:
JSCI 1860.1E

MEMBERSHIP OF JSC RADIATION SAFETY COMMITTEE

William M. Bland, Jr.	(NA)	Chairman
*Charles M. Barnes, D.V.M., Ph.D.	(SD5)	Alternate Chairman and Member
*Stuart A. Bergman, M.D.	(SD2)	Member
William G. Davis	(SN2)	Member
Carolyn Huntoon, Ph.D.	(SD4)	Member
John C. Welch	(JN3)	Member
Leonard A. Schluter, Ph.D.	(RF)	Member
Rodney G. Rose	(FA)	Member
Donald J. Mayhew	(LG)	Member
*D. Stuart Nachtwey, Ph.D.	(SD5)	Member

*Denotes change

LYNDON B. JOHNSON SPACE CENTER **ANNOUNCEMENT**	Date: 10/3/75 No: 75-62 Dist: S Approved: See Below
Subject: MULTISUBJECT INFORMATION	

2. RADIOLOGICAL HEALTH ACTIVITY. Detailed conduct and direction of the Center Radiological Health Activity is delegated to the Environmental Health Branch, Health Services Division, Life Sciences Directorate. The Environmental Health Branch and support contractor, as directed by the JSC Radiation Safety Committee, develop such guidelines and controls as are required to assure compliance by Center and contractor personnel with Federal Statutes, NRC regulations, JSC management issuances, conditions of federal licenses, and principles of good radiological health practice.

The JSC Radiological Health Manual provides detailed instructions to Center and contractor personnel regarding safe radiological practices, preparation of forms, and securing the cooperation and assistance of professional radiological health personnel.

Mr. Arnold W. Orsak, Kelsey-Seybold Clinic, has been designated as the JSC Radiological Safety Officer to administer the detailed Radiological Health Activity. He relates to NASA through the Environmental Health Branch. Other contractor professional health physicists are available to advise and assist the using organizations in the safe use of radiological materials and equipment.

Telephone numbers for the Radiological Health Activity are as follows:

Radiological Safety Officer.....5936
Environmental Health Branch.....5281
Radiological Health Laboratory.....6384

Rescission: JSCA 72-88, File 1860, dated June 6, 1972.

Richard S. Johnston
Director of Life Sciences

JOHNSON SPACE CENTER MANAGEMENT INSTRUCTION

Lyndon B. Johnson Space Center

NASA

DATE	NO
1/30/78	JSCI 1860.2A
RESP ORG	DIST
SD	A-3

APPROVED

Richard S. Johnston
Director of Space
and Life Sciences

MEDICAL ISOTOPES OPERATIONS SUBCOMMITTEE OF THE JSC RADIATION SAFETY COMMITTEE

1. PURPOSE. To establish the Medical Isotopes Operations Subcommittee of the JSC Radiation Safety Committee and to set forth its functions and membership.

2. ESTABLISHMENT. The Medical Isotopes Operations Subcommittee (hereafter referred to as the "Subcommittee") is established as a Subcommittee to the JSC Radiation Safety Committee to provide evaluations of all proposals for research, diagnosis and therapeutic use of radioisotopes in the Johnson Space Center programs. Its establishment is necessary in the public interest in connection with the use of radioisotopes on humans, in accordance with Federal regulatory matters. This Subcommittee is not a NASA Advisory Committee within the meaning and intent of NMI 1150.2C.

3. FUNCTIONS. In accordance with Title 10, Code of Federal Regulations Section 35.11, the Subcommittee will:

a. Review the training and experience in medical uses of radioactive material of physicians wishing to use radiopharmaceuticals, and approve those physicians who are to use or directly supervise the human use of radioactive material.

*b. Review, from the standpoint of radiological health and safety, and approve or disapprove requests for use of radioactive material or radiation-producing equipment in or on humans.

c. Evaluate and coordinate use of isotopes for medical purposes under a private practice or organizational license in or for JSC programs.

*4. RATIFICATION. Actions of the Subcommittee will be ratified by the JSC Radiation Safety Committee before implementation.

5. MEMBERSHIP

a. The Subcommittee will consist of no less than three members, including the Chairman and Executive Secretary, and will include physicians expert in internal medicine, hematology, therapeutic radiology, and a person experienced in assay of radioisotopes and protection against ionizing radiations.

b. The Chairman and Executive Secretary (who shall be full-time, salaried employees of NASA), and other members of the Subcommittee shall be appointed by the Director, Space and Life Sciences. The members shall be appointed on the basis of their qualifications and experience in the proposed use, handling, and administration of radioisotopes and, where applicable, their clinical management of radioactive patients. Special Government members shall serve for one-year terms. (See Attachment for a list of members.)

6. MEETINGS

a. Meetings shall be held at the call of the Chairman with an agenda furnished or approved by him. All meetings shall be conducted by the Chairman, or other designated full-time, salaried employee of NASA.

b. Minutes of the Subcommittee meetings shall, as a minimum, contain a record of persons present, a description of matters discussed and conclusions reached, and copies of all reports received, issued, or approved by the Subcommittee. The accuracy of all minutes shall be certified by a full-time, salaried officer or employee of NASA present during the proceedings recorded.

7. RECORDS AND STAFF SUPPORTING SERVICES

a. All records and files of the Subcommittee (including agenda, transcripts, or notes of meetings, studies, reports, or other data compilations or working papers made available to or prepared by the Subcommittee) will be maintained by the Space and Life Sciences Directorate.

b. Staff and supporting services will be provided by the Space and Life Sciences Directorate.

8. AVOIDANCE OF CONFLICTS OF INTEREST

a. Proposed nongovernmental members of the Subcommittee will be appointed as JSC experts or consultants before serving as members of the Subcommittee, thereby meeting the definition of "Special Government Employees" within the meaning of NHB 1900.2A, which sets forth guidance to NASA Special Government Employees regarding the avoidance of conflicts of interest and the observance of ethical standards of conduct. A copy of NHB 1900.2A will be furnished each nongovernmental member at the time of his appointment as a NASA consultant or expert.

b. NASA Form 1271, "NASA Special Government Employees Confidential Statement of Employment and Financial Interests," will be executed by each expert/consultant prior to his participation in any meeting.

*9. DURATION. The Subcommittee will continue until this Management Instruction is rescinded.

10. RESCISSION. JSCI 1860.2, dated November 4, 1974.

*Denotes change

1/30/78

Attachment to:
JSCI 1860.2A

MEMBERSHIP MEDICAL ISOTOPES OPERATIONS SUBCOMMITTEE
OF THE JSC RADIATION SAFETY COMMITTEE

Chairman:	*Stuart A. Bergman, Jr., M.D.
Executive Secretary:	*Charles M. Barnes, D.V.M., Ph.D.
Members:	*E. H. Harris, M.D.
	*Howard J. Glenn, M.D., University of Texas M. D. Anderson Hospital
	Thomas P. Haynie, M.D., University of Texas M. D. Anderson Hospital

*Denotes change

NASA-JSC

JOHNSON SPACE CENTER MANAGEMENT INSTRUCTION

Lyndon B. Johnson Space Center NASA

DATE	NO
12/9/77	JSCI 1860.5C
RESP. ORG.	DIST.
SA/NA	A-3

APPROVED

for S. A. Sjoberg
Christopher C. Kraft, Jr.
Director

RADIATION CONSTRAINTS PANEL

1. PURPOSE. To establish the functions and membership of the Radiation Constraints Panel.

2. APPLICABILITY. This Instruction is applicable to all Center elements.

3. FUNCTIONS. The Radiation Constraints Panel is responsible for coordinating all operational aspects of radiation pertaining to manned spaceflights managed by JSC. The Panel will perform the following specific functions:

a. Review operational aspects of radiation including coordination of exposure limits, mission objectives, crew and operational considerations, and program requirements to arrive at a consolidated Center position.

b. Coordinate and evaluate requirements for operational radiation instrumentation, and recommend appropriate action to the cognizant program office.

c. Review missions for radiation constraints, nominal exposure, trade-offs, contingencies, procedures, mission rules, and other mission considerations.

d. Review radiation support for each mission, including onboard instrumentation, the Mission Control Center, radiation network, other Government agencies, and additional support appropriate to the mission.

e. Collect, review, and publish for each mission a detailed listing of radiation sources on the vehicles being flown.

The Radiation Constraints Panel will determine the requirements and necessary support for each program and provide recommendations to the appropriate program manager for implementation.

4. MEMBERSHIP

a. Representatives of the following organizations will be members:

Data Systems and Analysis Directorate

* Space and Life Sciences Directorate

Engineering and Development Directorate

Flight Operations Directorate

Space Shuttle Program Office

Space Shuttle Orbiter Project Office

Safety, Reliability, and Quality Assurance Office

Shuttle Payload Integration and Development Office

b. Additional members may be appointed by the Chairman.

c. The Data Systems and Analysis Directorate representative will chair the Panel.

5. MEETINGS. The Radiation Constraints Panel meets as called by the Chairman.

6. RELATIONSHIPS. The Radiation Constraints Panel reports to the Director, JSC.

7. RECORDS AND STAFF SUPPORTING SERVICES. The Chairman is responsible for Panel records and files. The Data Systems and Analysis Directorate is responsible for providing staff and supporting services.

8. DURATION. The Panel will function until this Instruction is rescinded.

9. RESCISSION. JSCI 1860.5B, dated 9/8/76.

*Denotes change.

LYNDON B. JOHNSON SPACE CENTER

ANNOUNCEMENT

Date: 8/14/75 No: 75-51

Dist: S

Approved:
William M. Bland, Jr.
Chairman, Radiation Safety Committee

Subject: CONTROL OF RADIOACTIVE MATERIALS AND RADIATION PRODUCING DEVICES

JSC is required to control radioactive materials and radiation producing devices in compliance with the Code of Federal Regulations, Title 10, Nuclear Regulatory Commission, and Title 29, Part 1910.96, Department of Labor, Occupational Safety and Health Administration Standards.

JSCI 1860.4D, "Radiological Protection Policy," JSCI 1860.1C, "JSC Radiation Safety Committee," and JSCM 1860, "Radiological Health Manual," delegate the authority for this activity to the Radiological Safety Officer and the Radiation Safety Committee. The following instructions apply to NASA and contractor personnel at JSC facilities:

a. Procurement. All purchase requests for radioactive materials or radiation producing devices must be approved by the Environmental Health Branch (DD6), extension 5281.

b. Receipt. Procedures defining receiving instructions for radioactive material or radiation producing devices must include a requirement that JSC Radiological Health personnel perform a hazard determination upon receipt.

c. Shipment. All shipping documents for radioactive materials or radiation producing devices must be approved by the JSC Radiological Safety Officer, A. W. Orsak, extension 5936.

d. Use. The JSC Radiation Safety Committee must approve the use of any regulated source of ionizing radiation. A regulated source of ionizing radiation can be either a machine that produces ionizing radiation, or a radioactive material, defined as follows:

(1) Any machine that is capable of delivering more than 2 milliroentgens in any 1-hour period to a major portion of the body, or capable of producing injury to a small area of the body.

(2) Any Nuclear Regulatory Commission byproduct material considered a single source that exceeds the values stated in 10 CFR, Part 31, "General Licenses for Byproduct Materials," or natural-occurring Uranium, Radium, and Thorium sources that exceed 50 microcuries.

Questions related to the contents of this announcement should be addressed to J. Vernon Bailey, extension 3419.

APPENDIX B

GLOSSARY

accelerator	A machine that accelerates electrically charged particles to high velocities. Types of accelerators include the cyclotron, linear accelerator and Van de Graaff generator.
agreement state	Any state with which the Nuclear Regulatory Commission has entered into an effective agreement to perform specific parts of the Atomic Energy Act of 1954.
alpha radiation	Positively charged particles, each identical to a helium nucleus and emitted from a nucleus during radioactive decay.
alpha emitter	Any nuclide that emits alpha radiation.
beta radiation	High speed electrons each emitted from a nucleus during radioactive decay.
beta emitter	Any nuclide that emits beta radiation.
bremsstrahlung	Electromagnetic radiation emitted by charged particles when they are slowed down by electric fields in passage through matter.
byproduct material	Any radioactive material (excluding source and fissionable material) obtained in the process of producing or using source or fissionable material; includes fission products produced in nuclear reactors.
contamination (radioactive)	The presence of radioactive material anywhere it is not desired.
curie	The unit of radioactivity; equals 37 billion nuclear decays per second.
decay (radioactive)	Spontaneous disintegration of the nucleus of an unstable atom by the emission of charged particles and/or electromagnetic radiation.
decontamination	The removal of radioactive contaminants.
dose (radiation)	The quantity of energy imparted to a mass of material exposed to radiation.
dose rate	The radiation dose delivered per unit time.
dosimeter	Any device that detects and measures radiation dose.

film badge	A packet of photographic film used for measurement of radiation dose for personnel monitoring purposes.
fission	The splitting of a heavy nucleus into roughly equal parts, accompanied by the release of energy and frequently one or more neutrons.
fissionable material	Any material readily fissioned by slow neutrons.
gamma radiation	Highly penetrating electromagnetic radiation of nuclear origin.
half life (radioactive)	The time in which half the atoms in a radioactive substance decay.
health physics	A profession devoted to the protection of man and his environment from unwarranted radiation exposure.
ionization chamber	An instrument that detects and measures ionizing radiation by observing the electric current created when radiation ionizes gas in the chamber.
ionizing radiation	Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.
isotope	Atoms with same atomic number but different atomic weights.
licensed material	Any material received, possessed, used or transferred under a general or special license issued by the Nuclear Regulatory Commission or an agreement state.
micro-	A prefix meaning one-millionth, e.g., 1 microcurie = 1 x 10^{-6} curies.
milli-	A prefix meaning one-thousandth, e.g., 1 millicurie = 1 x 10^{-3} curies.
nuclide	Any species of atom that exists for a measurable length of time.
pocket dosimeter	A self-reading, pencil size ionization chamber used for personnel monitoring purposes.

quality factor	A factor used to compare the biological effectiveness of absorbed radiation doses due to different types of ionizing radiation; equivalent to the term, RBE, relative biological effectiveness.
rad	The basic unit of absorbed dose of ionizing radiation; equals the absorption of 100 ergs of energy per gram of matter.
radiation	a. The emission and propagation of energy through space or through a material in the form of waves. b. The energy propagated through space or through materials as waves; usually referring to electromagnetic radiation. c. By extension, particulates such as alpha or beta radiation or rays of mixed type.
radioactivity	The spontaneous decay or disintegration of an unstable atomic nucleus, accompanied by the emission of radiation.
radioassay	The process of analyzing biological material to determine its radioactive content.
radiography	The use of penetrating ionizing radiation to examine solid material.
radioisotope	An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation.
radiology	That branch of medicine which uses ionizing radiation for diagnosis and therapy.
rem	Roentgen equivalent man. A unit of absorbed dose in biological matter; equals the absorbed dose in rads multiplied by the quality factor of the radiation.
roentgen	The amount of gamma or X-radiation required to produce ions carrying one electrostatic unit of charge in one cubic centimeter of dry air under standard temperature and pressure conditions.

source material	Any material, except special nuclear material, which contains 0.05 percent or more of uranium, thorium or any combination of the two.
special nuclear material	Plutonium, uranium-233, uranium containing more than the natural abundance of uranium-235, or any material enriched by any of the substances.
survey	An evaluation of the radiation hazards incidental to the production, use or presence of radioactive materials or other sources of radiation under a specific set of conditions.
temporary job site	Any facility, utilized temporarily by a JSC sponsored project, that is not under the administrative control of the JSC.
waste (radioactive)	Equipment and materials which are radioactive and, having no further use, are discarded.
X-radiation	Penetrating electromagnetic radiation of non-nuclear origin; usually produced by bombarding a metallic target with high speed electrons.

APPENDIX C

JSC FORMS

1. Radioactive Material Use Authorization
   JSC Form 1942

2. Radiation Machine Use Authorization
   JSC Form 1943

3. Ionizing Radiation User Approval Request
   JSC Form 1944

4. Radioactive Material Transfer Receipt
   JSC Form 1625

RADIOACTIVE MATERIAL USE AUTHORIZATION

(Prepare in original and one copy.)

ORGANIZATION		DATE PREPARED	REF. NUMBER
Radioisotope Branch	☒ New Request ☐ Modification	Jan. 5, 1966	

1. TITLE OR BRIEF DESCRIPTION OF PROJECT:
Animal Studies using a radioactive tracer to develope an early disease detection procedure.

2. PROCEDURE INCLUDING SPECIAL TECHNIQUES AND SAFETY PRECAUTIONS: *(Information to be submitted on additional sheets in duplicate.)*	3. COMPLETION DATE
See Attachments 1 & 2	January, 1968

4. RADIOACTIVITY REQUIREMENTS

A. ELEMENT AND ISOTOPE	B. PHYSICAL FORM
Hydrogen-3	Liquid (Tritiated Thymidine)
C. TOTAL QUANTITY REQUIRED	**D. ESTIMATED ACTIVITY PER EXPERIMENT**
10 Millicuries	10 Microcuries/Procedure

5. LOCATION OF USE

☒ JSC ☐ Temporary Job Site *(Specify)* _____	BUILDING NUMBER	ROOM NUMBER
	266	16

6. USERS *(Submit supplemental form for each individual.)*	7. SIGNATURE OF REQUEST ORIGINATOR	DATE
Jane Doe; Mary Buck. (See Attachments 3,4.)		Jan.5,1966
USE SUPERVISOR	**TITLE OR POSITION**	**CODE**
Jane Doe	Principal Investigator	DQG

8. SIGNATURE OF TECHNICAL MANAGER OR NASA SUPERVISOR	DATE	10. RADIATION SAFETY COMMITTEE
	Jan.5,1966	☐ Disapproved
TITLE OR POSITION	**CODE**	☐ Approved, subject to conditions noted in Item 12
Branch Manager	DQG	

9. SIGNATURE - ENVIRONMENTAL HEALTH BRANCH	DATE	CHAIRMAN	DATE
TITLE OR POSITION	**CODE**	**11. EXPIRATION DATE**	
Radiological Safety Officer	DD 13		

12. An approved "Radioactive Material Use Authorization" shall be subject to all applicable rules, regulations, and orders of the JSC Radiation Safety Committee now or hereafter in effect and any conditions specified below:

a. Standard Conditions

(1) The Use Supervisor shall insure compliance with JSCM 1860A, JSC Radiological Health Manual and statements and procedures contained within this request.

(2) The Use Supervisor shall provide health and safety procedures covering radiological protection, control, and security of radioactive material, to each individual using or having responsibility for use of such material.

b. Special Conditions *(To be completed by Radiation Safety Committee.)*

RADIATION MACHINE USE AUTHORIZATION

(Prepare in original and one copy.)

ORGANIZATION		DATE PREPARED	REF. NUMBER
Contractors Hardware Quality Office	☒ New Request ☐ Modification	Jan. 5, 1966	

1. TITLE OR BRIEF DESCRIPTION OF PROJECT:
Industrial X-ray radiography--Non-destructive testing of flight related hardware prior to assembly.

2. PROCEDURE INCLUDING SPECIAL TECHNIQUES AND SAFETY PRECAUTIONS: *(Information to be submitted on additional sheets in duplicate.)* See Attachment No. 1.

3. MACHINE CHARACTERISTICS

A. MAKE	B. SERIAL NUMBER
Albatross	10001
C. MODEL	**D. MAXIMUM SETTING**
ABC-1	300 KVP 50 milliamp-minutes

4. LOCATION OF USE

BUILDING NUMBER	ROOM NUMBER	5. COMPLETION DATE
10	Northwest Hi-Bay X-ray Room	Duration of Current Mission (Late 1970)

6. USERS *(Submit supplemental form for each individual.)*	7. SIGNATURE OF REQUEST ORIGINATOR	DATE
I.C.Voids; N.D.Tester.(See Attachment 2.)		Jan.5,1966
USE SUPERVISOR	**TITLE OR POSITION**	**CODE**
N.D.Tester	X-ray Inspection Supervisor	Contrac-2

8. SIGNATURE OF TECHNICAL MANAGER OR NASA SUPERVISOR	DATE	10. RADIATION SAFETY COMMITTEE
		☐ Disapproved
TITLE OR POSITION	**CODE**	☐ Approved, subject to conditions noted in Item 12
Technical Manager	LJW-246	

9. SIGNATURE - ENVIRONMENTAL HEALTH BRANCH	DATE	CHAIRMAN	DATE
TITLE OR POSITION		**11. EXPIRATION DATE**	
Radiological Safety Officer	DD 13		

12. An approved "Radiation Machine Use Authorization" shall be subject to all applicable rules, regulations, and orders of the JSC Radiation Safety Committee now or hereafter in effect and any conditions specified below:

a. Standard Conditions

(1) The Use Supervisor shall insure compliance with JSCM 1860, JSC Radiological Health Manual and statements and procedures contained within this request.

(2) The Use Supervisor shall provide health and safety procedures covering radiological protection, control and security of radiation machines, to each individual using or having responsibility for use of such machines.

b. Special Conditions: *(To be completed by Radiation Safety Committee.)*

Ref. Number_____

IONIZING RADIATION USER APPROVAL REQUEST

Name_____ Employer_____

Supervisor or NASA Monitor Requesting Approval_____

TRAINING (Use supplemental sheets if necessary)

	Formal	Informal	Location	Duration
1. Principles and practices of radiation protection.	Yes No	Yes No		
2. Radioactivity measurements standardization and monitoring techniques and instruments.	Yes No	Yes No		
3. Biological effects of radiation.	Yes No	Yes No		

EXPERIENCE (Use supplemental sheets if necessary)

Type of X-ray/Accelerator and/or Nuclide	Maximum Energy and/or Curies	Purpose in Use	Location	Duration

I certify that I have read and understand the following:

	Yes	No
1. NRC Regulations, 10 CFR 19 and 20 or OSHA 29 CFR 1910.96	____	____
2. JSC Radiological Health Manual.	____	____
3. Local Procedures and Methods of Control.	____	____

Signature of User_____ Date_____

Approved:_____ Date_____
Chairman, JSC Radiation Safety Committee

JSC Form 1944

No. 5577

RADIOACTIVE MATERIAL TRANSFER RECEIPT

(See instructions on reverse side.)

BUDGET BUREAU NO. 104-R0039
Approval expires May 31, 1982

Portions of this report are both required and authorized by law. [Atomic Energy Act of 1954, 42 USCA S2011, et seq. (1973), as amended; the Energy Reorganization Act of 1974, 42 USCA S5801, et seq, (1973), as amended, (Supp. 1976); and CFR, Title 10.] Relevant provisions of the cited authorities provide that failure to report may result in revocation of license and/or the issuance of court orders and/or civil penalties and/or criminal prosecution for certain willful violations.

SECTION I - ORIGINATION INFORMATION (Originator complete this section)

A. ITEM DATA

(1) NAME OF ITEM

REF. NO. (PREVIOUS TRANSFER RECEIPT)

(2) SERIAL NUMBER

(3) ISOTOPE

(4) ACTIVITY (MILLICURIES)

(5) PHYSICAL AND CHEMICAL FORM OF RADIOACTIVE MATERIAL

(6) ACTIVITY DETERMINED BY *(Check one)*

☐ RECORD INFORMATION ☐ CALCULATION ☐ MEASURED BY: _____

DATE DETERMINED

(7) PURPOSE OF ITEM

(8) LEAK TEST CERTIFICATE PROVIDED WITH THIS TRANSFER? ☐ YES ☐ NO ☐ EXEMPT

B. ACCOUNTABILITY DATA

(1) TRANSFERRED FROM (LICENSEE'S NAME)

LICENSE NUMBER

(Check one)

☐ NRC ☐ STATE OF _____

(2) TRANSFERRED TO (LICENSEE'S NAME)

LICENSE NUMBER

(Check one)

☐ NRC ☐ STATE OF _____

C. RESPONSIBLE INDIVIDUAL (Shipper's Radiological Safety Officer)

(1) SIGNATURE

TITLE

DATE

TELEPHONE NO.

(2) ORIGINATING ORGANIZATION *(Complete address - Include Zip Code)*

D. SHIPPING DATA

(1) DATE SHIPPED

(2) ADDRESSED TO *(Include Zip Code)*

(3) MODE OF SHIPMENT *(Specify)*

(4) NAME OF CARRIER

(5) TRANSPORTATION DOCUMENTATION *(Give name & number of shipping document)*

SECTION II - DESTINATION INFORMATION (Receiver complete this section)

A. RECEIPT INFORMATION

(1) DATE ITEM RECEIVED

(2) CONDITION

(3) INFORMATION IN BLOCK _____ SHOULD BE CORRECTED TO:

B. RESPONSIBLE INDIVIDUAL (Receiver's Radiological Safety Officer)

SIGNATURE

TITLE

DATE

TELEPHONE NO.

C. DISPOSITION OF ITEM

(1) NAME OF CUSTODIAN

TELEPHONE NO.

(2) DISPOSITION AND LOCATION

JSC Form 1625 (Rev May 77)

RADIATION SAFETY OFFICER

APPENDIX D

JSC RADIOLOGICAL HEALTH INSTRUMENTATION

I. Portable Radiation Survey Instrumentation

II. Personnel Dosimetry Instrumentation

III. Secondary Standard and Calibration Instrumentation

IV. Analytical Laboratory Instrumentation

V. Laboratory Monitoring Instrumentation

NOTE: All instruments are available from the Biomedical Applications Branch, JSC.

RADIOLOGICAL HEALTH INSTRUMENTATION LIST

Below is a categorized list of Radiological Health equipment used in evaluations of occupational hazards:

I. Portable Radiation Survey Instrumentation

Item	Quantity	Description
1. Survey Meter	30	Civil Defense-Type 700 Survey Meter. A field instrument used for the detection of beta, X, and gamma radiation. Uses a halogen quenched Geiger-Mueller tube as the detector. Ranges of 0 - .5, 0 - 5, 0 - 50 milliroentgens per hour. Accessories include head phone and carrying strap.
2. Survey Meter	2	Victoreen Model 440 Low energy Survey Meter. A field instrument used for the detection of alpha, beta, X and gamma radiation. Detects low energy X and gamma radiation from 7 KeV to 1.3 MeV using an air-filled ion chamber. Five overlapping linear ranges from 0 - 3 to 0 - 300 milli-roentgens per hour.
3. Survey Meter	1	Victoreen Model 440 RF/C Low Energy, RF Shielded Survey Meter. A field instrument used for the detection of low energy X radiation emanating from color television sets and similar high voltage-rectifying devices. Electronically shielded from radio frequency fields. Detects X-rays from 12 KeV in five overlapping linear ranges of 0 - 1 to 0 - 100 milli-roentgens per hour. Meets recommendations of the National Council on Radiation Protection for low energy measurements.

Item	Quantity	Description
4. Survey Meter	2	Victoreen Model 490 Low Range Survey Meter. A field instrument used with either a GM or scintillation probe for the detection of alpha, beta, X and gamma radiation. Ranges of 0 - .2, 0 - 2, 0 - 20 milliroentgens per hour with GM probe and 0 - 800,000 counts per minute with scintillation probe.
5. Survey Meter	2	Ludlum Measurements Model 4 Geiger Counter. A field instrument using a GM tube for the detection of X and gamma radiation. Especially suited for industrial radiography surveys. Ranges of 0 - 10, 0 - 100, 0 - 1000 milliroentgens per hour.
6. Survey Meter	2	Reactor Experiment Digimaster Survey Meter. A field instrument using an internally housed GM tube for the detection of beta, X and gamma radiation. Has a push-button, digital readout display and indicates whether reading is in milliroentgens per hour or roentgens per hour. Ranges of 0 - 99.9 mR/hr. and 0 - 99.9 R/hr.
7. Survey Meter	1	Eberline Model PAC-4G Survey Meter. A field instrument using the gas proportional principle of detecting alpha and beta radiation. Operates on disposable, liquid propane gas cylinder with separate probes for alpha and beta detection. Especially useful for the detection of particulate contamination. Range of 0 - 100,000 counts per minute.
8. Survey Meter	1	Eberline Model PAC-4S Alpha Survey Meter. A field instrument using a scintillation probe to detect alpha radiation. Expecially useful for the detection of particulate contamination. Range of 0 - 2 x 10^6 counts per minute.

Item	Quantity	Description
9. Survey Meter	1	Total Teletector Model 6112 Survey Meter. A field instrument for measuring beta, X and gamma radiation. Has a GM telescopic probe extendable to 4 meters for increased operator safety. Ranges of 0 - .2, 0 - 50, 0 - 1000 milliroentgens per hour and 0 - 100, 0 - 1000 roentgens per hour.
10. Survey Meter	1	Eberline Model PNC-4 Neutron Counter. A field instrument for the detection of fast and slow neutron radiation. Has a BF_3 type detector with a cadmium shield and moderator. Ranges of 500, 5000, 50,000 counts per minute.

II. Personnel Dosimetry Instrumentation

Item	Quantity	Description
1. Pocket Dosimeters	196	Various makes and models of direct-reading, personal dosimeters for cumulatively measuring the amount of X and/or gamma radiation received by the wearer. All require a standard radiac dosimeter charger. Ranges: Victoreen Model 541A, 0 - 200 milli-roentgens; Bendix Model 611, 0 - 5 roentgens; Bendix Model 608, 0 - 10 roentgens; Bendix Model 730, 0 - 20 roentgens; Bendix Model 610, 0 - 50 roentgens; Bendix Model 742, 0 - 200 roentgens.
2. Dosimeter Charger	8	Victoreen Model 2000A Dosimeter Charger. A portable, battery-powered device for placing a charge on pocket dosimeters. Delivers 180 - 240 volts D.C.
3. Digital Dosimeter	2	Nuclear Associates Prima V Digital Dosimeter. A GM tube dosimeter for cumulatively measuring the amount of X and/or gamma radiation received by the wearer. Has push-button digital readout. A 9-volt transistor battery provides 400 hours of operation. Range of 0 - 1000 milliroentgens.

III. Secondary Standard and Calibration Instrumentation

	Item	Quantity	Description
1.	Exposure Standard	2	Victoreen Model 570 Condenser R-Meter. A highly accurate instrument for determining an accumulated exposure to X or gamma radiation. Particularly suited for calibrating X-ray beam output and radioactive source intensities. Six accessory detection chambers integrate radiation exposures from .025 to 250 roentgens at energies from 6 to 1300 KeV. Requires AC power outlet.
2.	Integrating Ratemeter	1	Victoreen Model 555 Radocon II. An instrument for measuring radiation exposure rate and/or accumulated exposure to X and gamma radiation. Useful for diagnostic applications including flux mapping, installation surveys and phantom measurements. Five accessory detection chambers measure dose rates from .003 to 1000 roentgens per minute at energies from 6 to 1300 KeV. Requires AC power outlet.
3.	Exposed Standard	1	Victoreen Femtometer. A highly accurate instrument for determining an accumulated exposure to X or gamma radiation. Particularly suited for calibrating X-ray beam output and radioactive source intensities. Three inter-comparison standards (chambers) are calibrated to within 1.0% of a primary standard at the National Bureau of Standards at Washington, D. C.

IV. Analytical Laboratory Instrumentation

Item	Quantity	Description
1. Gas Proportional Counter	1	Beckman Lowbeta II Gas Proportional Counter. A laboratory instrument used for the quantitative and qualitative analysis of low level alpha and beta-emitting radionuclides. Well suited for counting leak tests of sealed sources, swipe surveys and environmental samples. Counts alpha or beta particles or both simultaneously. Has controls for single sample manual operation or up to 100 sample automatic operation. Provides a printed tape of total count and counting time. Requires external supply of Argon-Methane (P-10) gas.
2. Multi-Channel Gamma Spectrometer	1	Nuclear Chicago Model 512-Channel Gamma Analyzer. A laboratory instrument used for the quantitative and qualitative analysis of gamma-emitting radionuclides. A 2-inch, sodium-iodide, well-type detection crystal provides for analyzing leak tests, swipe samples and environmental samples. Provides visual output via an oscilloscope plus permanent output via either teletype or magnetic tape.

V. Laboratory Monitoring Instrumentation

Item	Quantity	Description
1. Count Rate Meter	2	Ludlum Model 21 Ratemeter. An AC powered linear ratemeter for use with GM, scintillation or proportional detectors. Used to detect laboratory or personnel contamination by alpha, beta or gamma-emitting radionuclides. Can also be used as an area monitor in low intensity radiation fields. Range of 0 - 10^6 counts per minute in four overlapping scales. Has both audible and visible response.

Item	Quantity	Description
2. Count Rate Meter	2	Eberline Model RM-3A Ratemeter. An AC powered linear ratemeter for use with GM, scintillation or proportional detectors. Used to detect laboratory or personnel contamination by alpha, beta or gamma-emitting radionuclides. Can also be used as an area monitor in low intensity radiation fields. Range of 0 - 5 x 10^4 counts per minute. Has both audible and visible response.
3. Tritium Monitor	1	Johnson Model 955B Tritium Monitor. A laboratory instrument for monitoring concentrations in air of radioactive hydrogen (tritium). Useful for detecting excessive levels of tritium in work areas and for detecting spills or leaks from containers of tritium. Has adjustable audible alarm. Can be adapted for use with Carbon-14 and Radon gases. Range of 0 - 10^4 micro-curies tritium per cubic meter of air in four linear scales.
4. Tritium Monitor	1	Texas Nuclear Tritium Sniffer. A laboratory instrument for monitoring concentrations in air of radioactive hydrogen (tritium). Useful for detecting excessive levels of tritium in work areas and for detecting spills or leaks from containers of tritium. Has adjustable audible alarm. Can be adapted for use with Carbon-14 and Radon gases. Range of 0 - 10^5 micro-curies tritium per cubic meter of air in four linear scales.

APPENDIX E

MEDICAL ISOTOPES OPERATIONS SUBCOMMITTEE GUIDELINES

JSCM 1860

JSC MEDICAL ISOTOPES OPERATIONS SUBCOMMITTEE GUIDELINE FOR AUTHORIZING HUMAN USES OF RADIOACTIVE MATERIAL

A. Purpose - To establish guidelines and criteria for authorizing the internal or external administration of radioactive material, or the radiation therefrom, to human beings under U. S. Nuclear Regulatory Commission Licenses issued to the Johnson Space Center for such purposes.

B. Scope - The human use of radionuclides authorized by this committee shall be limited to volunteer subjects for the purpose of measuring the response of body processes to the effects of space flight, simulation of space flight, or research in support of basic physiological principles in one or more parameters.

C. Applications

1. Application will be accepted from any qualified physician whose relationship with the Johnson Space Center is (a) staff member (b) consultant to JSC, or (c) employee of a contractor to JSC.

2. The application will be reviewed by radiological health staff before being considered by the committee.

3. The application must include a protocol of the proposed study. The submission should include the following information:

   a. Title of study.

   b. Brief statement of proposed study including objectives and rationale.

   c. The plan of investigation in sufficient detail to permit a critical evaluation of the methods for conducting the experiments and the controls established.

   d. A statement as to whether any planned complementary drug or radioisotope administration is contemplated in conjunction with the study.

   e. A statement about the expected fate of the isotope administrated.

f. References and a brief abstract prepared by the applicant of published or unpublished material, including information on localization, effective half-life, and radiation dosage. (The brochure of a commercial supplier is not a satisfactory authority for this purpose. It is not necessary to include with the application reprints of references).

g. A description of the human subjects to be studied, which shall include number, method of selection, age range, and sex. (Pregnant women shall be excluded from any test not involving the condition of pregnancy itself).

h. Confirmation that consent of human subjects, or their representatives, will be obtained to participate in the investigation except where this is not feasible or, in the investigator's professional judgment, is contrary to the best interests of the subjects.

i. The dose range (microcuries or millicuries) to be administered and the method of administration.

j. Calculations of the radiation doses delivered to the whole body and to the critical organ(s). The calculations shall contain information about:

(1) The expected half-life in various organs.

(2) The relationship between the retained isotope and the permissible body burden for occupational exposure.

(3) The rationale for using the dose selected.

(4) The radiation dose due to other simultaneous or accompanying radioactive isotope test which may be administered.

k. A statement of the institutional resources available to support the study including:

(1) Physical facilities and equipment expecially suited for the study under consideration.

(2) Availability of clinical material.

(3) Types of consultation or collaboration available including the name of the sponsor of the study if other than the applicant.

1. Qualifications of the individual physician who will be responsible for the study, including a summary or research training and experience and pertinent training or experience in the use of radioisotopes.

m. Estimated time needed to complete the study.

n. A schedule for reporting results of the study, and an outline of the type of information to be included in the report. The schedule can be in terms of time intervals or number or subjects studied. If studies are to be long range, interim reports should be provided.

D. Review of Application

1. Applications for human use of radionuclides shall be reviewed by health physicists of the radiological health staff and other specialists as appropriate to determine that:

a. Dosimetric calculations are correct or that there is adequate published documentation of expected dosages.

b. Critical organs are correctly stated.

c. Procedures and facilities reasonably assure safe handling.

d. Condition of licenses and all applicable rules and regulations are met.

e. Training and experience of using physicians and assisting personnel, as necessary, meet the intent of Appendix C, Acceptable Training and Experience for Medical Uses of Byproduct Material, NRC Licensing Guide - Medical Program, November 1965 or subsequent edition. (See Attachment No. 1).

2. Application for human use of radionuclides shall be reviewed by the Medical Isotopes Operations Subcommittee to determine that:

a. The application has been reviewed by the radiological health staff and meets established guidelines.

b. The proposed study will yield the specific data the investigator wishes to obtain and that the study is specifically related to the mission of the Johnson Space Center.

c. The subject will not be exposed to undue risk and will be fully informed as to nature and purpose of the investigation and as to effect upon subject's health. This should be supported by a statement from the subject or from the investigator that such disclosure was made to be placed in committee files.

ACCEPTABLE TRAINING AND EXPERIENCE FOR MEDICAL USES OF RADIOACTIVE MATERIAL

A. General

A physician may be approved by the Medical Isotopes Operations Subcommittee for human use or to directly supervise human use of radioactive material. To qualify as adequately trained, a physician's background should include:

1. General training in basic radioisotope handling techniques including:

   a. A working knowledge of:

      (1) Principles and practices of radiological health safety.

      (2) Radioactivity measurements, standardization, and monitoring techniques and instruments.

      (3) Mathematics and calculations basic to the use and measurement of radioactivity.

      (4) Biological effects of radiation.

   b. Experience in the use of radioactive material for the types and quantities for which the application is being made, or equivalent experience.

2. Investigative radioisotope training consisting of:

   a. Collaboration in examination of subjects to determine suitability for radioisotopic techniques.

   b. Collaboration in calibration of the dose and the actual administration of the dose to the subject, including calculation of radiation dose, related measurements, and plotting of data.

   c. Adequate period of training to enable the physician to manage radioactive subjects and to follow subjects through the investigation.

d. tudy and discussion with the principal investigator to establish most appropriate radioisotope procedures, limitations, contraindications, etc.

B. Specific

Training and experience criteria for use of standard clinical procedures in the manned space flight program are:

At lease thirty (30) hours of training in basic radioisotope handling techniques, such as the Oak Ridge Institute of Nuclear Studies "Basic Course in Radioisotopes Techniques" or its equivalent.

APPENDIX F

REFERENCES

APPENDIX F

REFERENCES (Available from Biomedical Applications Branch)

CODE OF FEDERAL REGULATIONS (CFR)

Title 10 - Energy

- Part 19 - Notices, Instructions and Reports to Workers: Inspection
- Part 20 - Standards for Protection against Radiation
- Part 30 - Licensing of Byproduct Material
- Part 31 - General Licenses for Certain Quantities of Byproduct Material and Byproduct Material Contained in Certain Items
- Part 33 - Specific Licenses of Broad Scope for Byproduct Material
- Part 35 - Human Uses of Byproduct Material
- Part 36 - Export and Import of Byproduct Material
- Part 40 - Licensing of Source Material
- Part 70 - Special Nuclear Material
- Part 71 - Packaging of Radioactive Material for Transport

Title 29 - Occupational Health and Safety Administration

- Part 1910.96 - Ionizing Radiation

RULES AND REGULATIONS OF STATES (Particularly in Nuclear Regulatory Commission (NRC) Agreement States)

PROVISIONS OF SPECIFIC NRC AND STATE LICENSES

Title 14 - U. S. Department of Transportation

- Part 103 - Federal Aviation Administration

Title 39 - U. S. Postal Regulations

- Part 124-125 - Code of Federal Regulations

Title 46 - U. S. Department of Transportation

- Parts 146-149 - Coast Guard Regulations

JSC Radiological Health Manual

Title 49 - U. S. Department of Transportation

Parts 171-178 - Rules and Regulations

U. S. POSTAL GUIDE, Part I, Article 37, Chapter IV, Radioactive Materials

NATIONAL BUREAU OF STANDARDS HANDBOOKS AND NATIONAL COMMITTEE ON RADIATION PROTECTION REPORTS

Handbook 48, 1951, Control and Removal of Radioactive Contamination in Laboratories. NCRP Report No. 8

Handbook 50, 1952, X-ray Protection Design

Handbook 51, 1952, Radiological Monitoring Methods and Instruments NCRP Report No. 10

Handbook 59, 1959, Permissible Dose from External Sources of Ionizing Radiation. NCRP Report No. 17

Handbook 63, 1957, Protection Against Neutron Radiation up to 30 MeV. NCRP Report No. 20

Handbook 69, 1959, Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air and in Water for Occupational Exposure. NCRP Report No. 22

Handbook 73, 1960, Protection Against Radiation from Sealed Gamma Sources. NCRP Report No. 24

Handbook 75, 1961, Measurement of Absorbed Dose of Neutrons, and Mixtures of Neutrons and Gamma Rays. NCRP Report No. 25

Handbook 76, 1961, Medical X-ray Protection up to 3 MeV. NCRP Report No. 26

Handbook 77, 1961, Precision Measurement and Calibration. Vol III, Optics, Metrology, and Radiation

Handbook 80, 1961, A Manual of Radioactivity Procedures. NCRP Report No. 28

Handbook 84, 1962, Radiation Quantities and Units. (International Commission on Radiological Units and Measurements (ICRU Report 10a)

Handbook 85, Physical Aspects of Irradiation. (ICRU Report 10b)

Handbook 86, 1963, Radioactivity. (ICRU Report 10c)

Handbook 89, 1963, Methods of Evaluating Radiological Equipment and Materials. (ICRU Report 10f)

Handbook 92, 1964, Safe Handling of Radioactive Materials. NCRP Report No. 30

Handbook 93, 1964, Safety Standard for Non-medical X-ray and Sealed Gamma-ray Sources, Part I. General. USASI Standard Z54.1 - 1963

Handbook 97, 1964, Shielding for High-energy Electron Accelerator Installations. NCRP Report No. 31

NCRP Report No. 29, 1962, Exposure to Radiation in an Emergency

NCRP Report No. 33, 1968, Medical X-ray and Gamma-ray Protection for Energies up to 10 MeV - Equipment Design and Use

FEDERAL RADIATION COUNCIL

Report No. 1, 1960, Background Material for the Development of Radiation Protection Standards

Report No. 2, 1961, Background Material for the Development of Radiation Protection Standards

Report No. 5, 1964, Background Material for the Development of Radiation Protection Standards

INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION (ICRP) REPORTS

ICRP Publication, Radiation Protection - Main Commission Report (1958), Pergamon Press

ICRP Publication 2, Report of Committee II on Permissible Dose for Internal Radiation (1959), Pergamon Press (Health Physics, June 1960)

ICRP Publication 3, Report of Committee III on Protection Against X-rays up to Energies of 3 MeV and Beta and Gamma Rays from Sealed Sources, (1960), Pergamon Press

ICRP Publication 4, Report of Committee IV on Protection Against Electromagnetic Radiation above 3 MeV and Electrons, Neutrons and Protons, (1964), Pergamon Press

ICRP Publication 5, Report of Committee V on Handling and Disposal of Radioactive Material in Hospitals and Medical Research Establishments, (1965)

ICRP Publication 6, Amendment to ICRP Publication 2, (1964)

ICRP Publication 7, Principles of Environmental Monitoring Related to Handling of Radioactive Material - A Report Prepared by a Task Group of Committee IV, (1966), Pergamon Press

ICRP Publication 8, Evaluation of Risk of Radiation - A Report Prepared by a Task Group of Committee III, (1966), Pergamon Press

ICRP Publication 9, Recommendations of the International Committee on Radiological Protection, (1966), Pergamon Press

ADDITIONAL REFERENCES

Health Physics, Journal of the Health Physics Society (monthly)

Radiological Health Handbook, U. S. Public Health Service, PB 121 784 R

APPENDIX G

U. S. Nuclear Regulatory Commission Regulations and Guides

1. Notices, Instructions and Reports to Workers; Inspections (10 CFR 19).

2. Standards for Protection Against Radiation (10 CFR 20).

3. Instruction Concerning Prenatal Radiation Exposure (Regulatory Guide 8.13).

PART 19

NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS; INSPECTIONS

Sec.

AUTHORITY: Secs. 53, 63, 81, 103, 104, 161, Pub. L. 83-703, 68 Stat. 930, 933, 935, 936, 937, 948, as amended (42 U.S.C. 2073, 2093, 2111, 2133, 2134, 2201); Sec. 401, Pub. L. 93-438, 88 stat. 1254 (42 U.S.C. 5891)

40 FR 8774

§ 19.1 Purpose.

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

§ 19.2 Scope.

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

38 FR 22217

§ 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, or 70 of this chapter, including licenses to operate a production or utilization facility pursuant to Part 50 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

§ 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.

40 FR 8774

§ 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.

38 FR 22217

§ 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.

38 FR 22217

(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.

40 FR 8774

(c) Form NRC-3, "Notice to Employees", shall be posted by each licensee wherever individuals work in or frequent any portion of a restricted area.

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

§ 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:

38 FR 22217

> 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.

§ 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.

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

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

§ 19.15 Consultation with workers during inspections.

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

(b) During the course of an inspection any worker may bring privately to the attention of the 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 Director of the appropriate Commission Regional Office, or to Commission inspectors. Any such notice shall be in writing, shall set forth the specific grounds for the notice, and shall be signed by the worker or representative of workers. A copy shall be provided the licensee by the Director of Inspection and Enforcement, Regional Office Director, or the inspector no later than at the time of inspection except that, upon the request of the worker giving such notice, his name and the name of individuals referred to therein shall not appear in such copy or on any record published, released, or made available by the Commission, except for good cause shown.

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(b) If, upon receipt of such notice, the Director of Inspection and Enforcement or Regional Office Director determines that the complaint meets the requirements set forth in paragraph (a) of this section, and that there are reasonable grounds to believe that the alleged violation exists or has occurred, he shall cause an inspection to be made as soon as practicable, to determine if such alleged violation exists or has occurred. Inspections pursuant to this section need not be limited to matters referred to in the complaint.

(c) No licensee shall discharge or in any manner discriminate against any worker because such worker has filed any complaint or instituted or caused to be instituted any proceeding under the regulations in this chapter or has testified or is about to testify in any such proceeding or because of the exercise by such worker on behalf of himself or others of any option afforded by this part.

§ 19.17 Inspections not warranted; informal review.

(a) If the Director of Inspection and Enforcement or of the appropriate Regional Office determines, with respect to a complaint under § 19.16, that an inspection is not warranted because there are no reasonable grounds to believe that a violation exists or has occurred, he shall notify the complainant in writing of such determination. The complainant may obtain review of such determination by submitting a written statement of posi-

tion with the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, who will provide the licensee with a copy of such statement by certified mail, 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, modify, or reverse the determination of the Director of Inspection and Enforcement or of the appropriate Regional Office and furnish the complainant and the licensee a written notification of his decision and the reason therefor.

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

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§ 19.30 Violations.

40 FR 8774

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 section 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 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.

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§ 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 8774

PART 20 STANDARDS FOR PROTECTION AGAINST RADIATION

GENERAL PROVISIONS

PERMISSIBLE DOSES, LEVELS, AND CONCENTRATIONS

PRECAUTIONARY PROCEDURES

WASTE DISPOSAL

RECORDS, REPORTS, AND NOTIFICATION

EXCEPTIONS AND ADDITIONAL REQUIREMENTS

ENFORCEMENT

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

§ 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. [40 FR 8774]

(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 exposure to such material and to radiation from such material, when added to exposures to unlicensed radioactive material and to other unlicensed sources of radiation in the possession of the licensee, and to radiation therefrom, does not exceed the standards for radiation protection prescribed in the regulations in this part. [25 FR 10914]

(c) In accordance with recommendations of the Federal Radiation Council, approved by the President, persons engaged in activities under licenses issued by the Nuclear Regulatory Commission pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974 should, in addition to complying with the requirements set forth in this part, make every reasonable effort to maintain radiation exposures, and releases of radioactive materials in effluents to unrestricted areas, as low as is reasonably achievable. The term "as low as is reasonably achievable" means as low as is reasonably achievable taking into account the state of technology, and the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to the utilization of atomic energy in the public interest. [40 FR 58847]

§ 20.2 Scope.

The regulations in this part apply to all persons who receive, possess, use, or transfer material licensed pursuant to the regulations in Parts 30 through 35, 40, or 70 of this chapter, including persons licensed to operate a production or utilization facility pursuant to Part 50 of this chapter. [40 FR 8774]

§ 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. [40 FR 12557]

(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 Part 30, 40, or 70 of this chapter. "Licensee" means the holder of such license;

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

(11) "Person" means (i) any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency other than the Commission or the Administration (except that the Administration shall be considered a person within the meaning of the regulations in this part to the extent that its facilities and activities are subject to the licensing and related regulatory authority of the Commission pursuant to section 202 of the Energy Reorganization Act of 1974 (88 Stat. 1244)), any State, any foreign government or nation or any political subdivision of any such government or nation, or other entity; and (ii) any legal successor, representative, agent, or agency of the foregoing.

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

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

(14) "Restricted area" means any area access to which is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. "Restricted area" shall not include any areas used as residential quarters, although a separate room or rooms in a residential building may be set apart as a restricted area;

(15) "Source material" means (i) uranium or thorium, or any combination thereof, in any physical or chemical form; or (ii) ores which contain by weight one-twentieth of one percent (0.05%) or more of *a*. uranium, *b*. thorium or *c*. any combination thereof. Source material does not include special nuclear material.

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

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

(18) "Administration" means the Energy Research and Development Administration or its duly authorized representatives.

(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.

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

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

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

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

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

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

NEUTRON FLUX DOSE EQUIVALENTS

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

(d) For determining exposures to X or gamma rays up to 3 Mev, the dose limits specified in §§ 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) [1] = 0.001 curie (Ci) [1] = 3.7×10^7 dps.

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

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

25 FR 10914; 40 FR 8774; 25 FR 10914; 25 FR 13952; 25 FR 10914; 27 FR 5906; 25 FR 10914; 25 FR 13952; 40 FR 8774; 25 FR 10914; 38 FR 29314

(b) [Deleted 40 FR 59704.]

(c) [Deleted 39 FR 23990.]

25 FR 10914

§ 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.

40 FR 8774

§ 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.

25 FR 10914

** PERMISSIBLE DOSES, LEVELS, AND CONCENTRATIONS

§ 20.101 Exposure of individuals to radiation in restricted areas.

(a) Except as provided in paragraph (b) of this section, no licensee shall possess, use, or transfer licensed material in such a manner as to cause any individual in a restricted area to receive in any period of one calendar quarter from radioactive material and other sources of radiation in the licensee's possession a dose in excess of the limits specified in the following table:

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

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

(1) During any calendar quarter the dose to the whole body from radioactive material and other sources of radiation in the licensee's possession shall not exceed 3 rems; and

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

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

25 FR 10914

§ 20.102 Determination of accumulated dose.

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

(b) Before permitting any individual in a restricted area to receive exposure to radiation in excess of the limits specified in paragraph (a) of § 20.101, 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).

41 FR 18300

(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 applies:

25 FR 10914

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

41 FR 52300

§ 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 intake of radioactive material by any organ from either inhalation or absorption or both routes of intake[4][5] in any calendar quarter does not exceed that which would result from inhaling such radioactive material for 40 hours per week for 13 weeks at uniform concentrations specified in Appendix B, Table I, Column 1.

(2) No licensee shall possess, use, or transfer mixtures of U–234, U–235, and

[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 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 materials shall be subject to the precautionary procedures required by § 20.103(b)(1).

[3] Multiply * the concentration values specified in Appendix B, Table I, column 1 by 6.3×10^5 ml to obtain the quarterly quantity limit.

Footnotes 4 and 5 on page 20-4.

* Amended 42 FR 20138.

** Amended 36 FR 1466.

U–238 in soluble form in such a manner as to permit any individual in a restric[illegible] 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[1] does not exceed that which would result from inhaling such material at the limits specified in Appendix B, Table I, Column 1 and footnote 4 thereto.

(3) For purposes of determining compliance with the requirements of this section the licensee shall use suitable measurements of concentrations of radioactive materials in air for detecting and evaluating airborne radioactivity in restricted areas and in addition, as appropriate, shall use measurements of radioactivity in the body, measurements of radioactivity excreted from the body, or any combination of such measurements as may be necessary for timely detection and assessment of individual intakes of radioactivity by exposed individuals. It is assumed that an individual inhales radioactive material at the airborne concentration in which he is present unless he uses respiratory protective equipment pursuant to paragraph (c) of this section. When assessment of a particular individual's intake of radioactive material is necessary, intakes less than those which would result from inhalation for 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)(ii).

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

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

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

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

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

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

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

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

[2] 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.

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

41 FR 52300

41 FR 52300

41 FR 52300

25 FR 10914

25 FR 10914

26 FR 14434

§ 20.104 Exposure of minors.

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

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

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

§ 20.105 Permissible levels of radiation in unrestricted areas.

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

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

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

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

§ 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; 29 FR 14434

(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. 29 FR 14434

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

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

§ 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. 25 FR 10914

§ 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 may be necessary for him to comply with the regulations in this part.

§ 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;

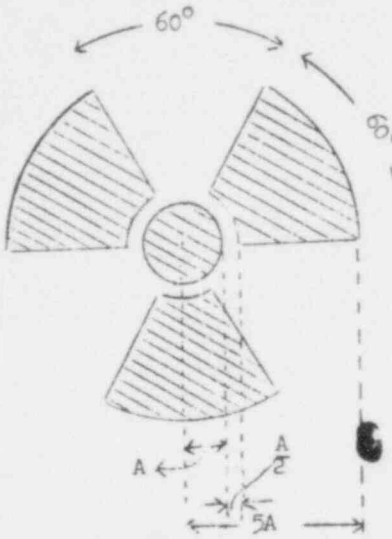
(3) "High radiation area" means any area, accessible to personnel, in which there exists radiation originating in whole or in part within licensed material at such levels that a major portion of the body could receive in any one hour a dose in excess of 100 millirem.

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

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

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

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

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

CAUTION [1]
AIRBORNE RADIOACTIVITY AREA

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

CAUTION [1]
RADIOACTIVE MATERIAL(S)

(2) Each area or room in which natural uranium or thorium is used or stored in an 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 subparagraph (3) of this paragraph, each container of licensed mate-

[1] Or "Danger."

25 FR 10914
35 FR 5033
35 FR 5033
35 FR 5033

rial shall bear a durable, clearly visible label identifying the radioactive contents.

(2) A label required pursuant to subparagraph (1) of this paragraph shall bear the radiation caution symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL". It shall also provide sufficient information[1] to 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 subparagraph (1) of this paragraph, 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 Column 2, Table I, Appendix B of this part.

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

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

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

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

31 FR 10614

§ 20.204 Some 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.

25 FR 10914

(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.

35 FR 5033

(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.

25 FR 10914

(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.

35 FR 5033

§ 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.

39 FR 17972

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

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

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

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

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

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

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

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

TABLE OF EXEMPT AND TYPE A QUANTITIES

Transport group[1]	Exempt quantity limit (in millicuries)	Type A quantity limit (in curies)
I	.01	0.001
II	0.1	0.050
III	1	3
IV	1	20
V	1	20
VI	1	1000
VII	25,000	1000
Special Form	1	20

39 FR 17972

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

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

41 FR 16445

(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 17972

§ 20.206 Instruction of personnel.

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

38 FR 22220

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

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

* [Amended 41 FR 16445.]

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

†Amended 41 FR 16445.

§ 20.207 Storage and control of licensed materials in unrestricted areas. 40 FR 26679

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

(b) Licensed materials in an unrestricted area and not in storage shall be tended under the constant surveillance and immediate control of the licensee.

WASTE DISPOSAL

§ 20.301 General requirement.

No licensee shall dispose of licensed material except:

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

(b) As authorized pursuant to § 20.302; or

(c) As provided in § 20.303 or § 20.304, applicable respectively to the disposal of licensed material by release into sanitary sewerage systems or burial in soil, or in § 20.106 (Radioactivity in Effluents to Unrestricted Areas).

§ 20.302 Method for obtaining approval of proposed disposal procedures. 25 FR 10914

*(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 to receive licensed material from other persons for disposal on land not owned by the Federal government or by a State government. 26 FR 352

(c) 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. 36 FR 23138

§ 20.303 Disposal by release into sanitary sewerage systems. 25 FR 10914

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 subparagraphs (1) or (2) of this paragraph:

(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 released into the sewerage system by the licensee does not exceed one curie per year.

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

§ 20.304 Disposal by burial in soil. 25 FR 10914

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

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

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

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

§ 20.305 Treatment or disposal by incineration.

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

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 20.205(c), and disposals made under §§ 20.302, 20.303, and 20.304. 39 FR 17972

(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. 41 FR 18300

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

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

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

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

§ 20.102 Reports of theft or loss of licensed material. 34 FR 7500

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

(b) Each licensee who is required to make a report pursuant to paragraph (a) of this section shall, within thirty (30) days after he learns of the loss or theft, make a report in writing to the appropriate NRC Regional Office listed in Appendix D with copies to the Director of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, setting forth the following information: 41 FR 16445

*Redesignated 36 FR 23138.

†Amended 42 FR 43965.

(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.

34 FR 7500

§ 20.403 Notifications of incidents.

41 FR 16445

(a) *Immediate notification.* Each licensee shall immediately notify by telephone and telegraph, mailgram, or facsimile, the Director of the appropriate NRC Regional Office listed in Appendix

D of any incident involving byproduct, source, or special nuclear material possessed by him and which may have caused or threatens to cause:

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

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

(3) A loss of one working week[1] or more of the operation of any facilities affected; or

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

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

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

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

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

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

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

§ 20.404 [Deleted 38 FR 22220.]

§ 20.405 Reports of overexposures and excessive levels and concentrations.

(a) In addition to any notification required by § 20.403, each licensee shall make a report in writing within 30 days to the appropriate NRC Regional Office listed in Appendix D with a copy to the Director of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, of:

(1) each exposure of an individual to radiation in excess of the applicable limits in §§ 20.101 or 20.104(a) or the license; (2) each exposure of an individual to radioactive material in excess of the applicable limits in §§ 20.103(a)(1), 20.103(a)(2), 20.104(b) or the license; (3) levels of radiation or concentrations of radioactive material in a restricted area in excess of any other applicable limit in the license; (4) any incident for which notification is required by § 20.403; and (5) 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. Each report required under this paragraph shall describe the extent of exposure of persons to radiation or to radioactive material, including estimates of each individual's exposure as required by paragraph (b) of this section; levels of radiation and concentrations of radioactive material involved; the cause of the exposure, levels or concentrations; and corrective steps taken or planned to assure against a recurrence.

(b) Any report filed with the Commission pursuant to 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) [Deleted 38 FR 22220.]

§ 20.406 [Deleted 38 FR 22220.]

§ 20.407 Personnel exposure and monitoring reports.

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

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

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

(3) Possess or use at any one time, for purposes of fuel processing, fabrication, 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; or

(4) Possess or use at any one time, for processing or manufacturing for distribution pursuant to Part 30, 32, or 33 of this chapter, byproduct material in quantities exceeding anyone 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

(b) Each person described in paragraph (a) of this section shall, within the first quarter of each calendar year, submit to the Director of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555,† the following reports, applicable to the described licensed activities covering the preceding calendar year:[2]

(1) A report of either (i) 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 (ii) the total number of individuals for whom personnel monitoring was provided during the calendar year; *Provided*, that such total includes at least the number of individuals required to be reported under paragraph (b)(1)(i) of this section. The report shall indicate whether it is submitted in accordance with paragraph (b)(1)(i) or (ii) of this section.

(2) 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 § 20.407(b)(1), 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)[3]	*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+	

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.

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

When an individual terminates employment with a licensee subject to § 20.407, or an individual assigned to work in such a licensee's facility, but not employed by the licensee, completes his work assignment in the licensee's facility, the licensee shall furnish* to the Director of Inspection and Enforcement,† U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, a report of the individual's exposure to radiation and radioactive material, incurred during the

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

†Amended 41 FR 16445.

‡Amended 42 FR 43965.

[2] 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.

[3] Individual values exactly equal to the values separating Exposure Ranges shall be reported in the higher range.

* Amended 38 FR 22220.

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.

34 F 4

§ 20.409 Notifications and reports to individuals.

38 FR 22220

(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.

EXCEPTIONS AND ADDITIONAL REQUIREMENTS

§ 20.501 Applications for exemptions.

25 FR 10914

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.

§ 20.601 Violations.

40 FR 8774

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.

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

APPENDIX A [Reserved]

April 30, 1975

20+0

25 FR 10914

APPENDIX B

Concentrations in Air and Water Above Natural Background

(See footnotes on page 20-15)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Actinium (89)	Ac 227	S	2×10^{-12}	6×10^{-5}	8×10^{-14}	2×10^{-6}
		I	3×10^{-11}	9×10^{-3}	9×10^{-13}	3×10^{-4}
	Ac 228	S	8×10^{-8}	3×10^{-3}	3×10^{-9}	9×10^{-5}
		I	2×10^{-8}	3×10^{-3}	6×10^{-10}	9×10^{-5}
Americium (95)	Am 241	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		* I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Am 242m	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	3×10^{-10}	3×10^{-3}	9×10^{-12}	9×10^{-5}
	Am 242	S	4×10^{-8}	4×10^{-3}	1×10^{-9}	1×10^{-4}
		I	5×10^{-8}	4×10^{-3}	2×10^{-9}	1×10^{-4}
	Am 243	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Am 244	S	4×10^{-6}	1×10^{-1}	1×10^{-7}	5×10^{-3}
		I	2×10^{-5}	1×10^{-1}	8×10^{-7}	5×10^{-3}
Antimony (51)	Sb 122	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
	Sb 124	S	2×10^{-7}	7×10^{-4}	5×10^{-9}	2×10^{-5}
		I	2×10^{-8}	7×10^{-4}	7×10^{-10}	2×10^{-5}
	Sb 125	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	3×10^{-8}	3×10^{-3}	9×10^{-10}	1×10^{-4}
Argon (18)	A 37	Sub[2]	6×10^{-3}		1×10^{-4}	
	A 41	Sub	2×10^{-6}		4×10^{-8}	
Arsenic (33)	As 73	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	5×10^{-4}
		I	4×10^{-7}	1×10^{-2}	1×10^{-8}	5×10^{-4}
	As 74	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	5×10^{-5}
		I	1×10^{-7}	2×10^{-3}	4×10^{-9}	5×10^{-5}
	As 76	S	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
		I	1×10^{-7}	6×10^{-4}	3×10^{-9}	2×10^{-5}
	As 77	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Astatine (85)	At 211	S	7×10^{-9}	5×10^{-5}	2×10^{-10}	2×10^{-6}
		I	3×10^{-8}	2×10^{-3}	1×10^{-9}	7×10^{-5}
Barium (56)	Ba 131	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Ba 140	S	1×10^{-7}	8×10^{-4}	4×10^{-9}	3×10^{-5}
		I	4×10^{-8}	7×10^{-4}	1×10^{-9}	2×10^{-5}
Berkelium (97)	Bk 249	S	9×10^{-10}	2×10^{-2}	3×10^{-11}	6×10^{-4}
		I	1×10^{-7}	2×10^{-2}	4×10^{-9}	6×10^{-4}
	Bk 250	S	1×10^{-7}	6×10^{-3}	5×10^{-9}	2×10^{-4}
		I	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
Beryllium (4)	Be 7	S	6×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-3}
		I	1×10^{-6}	5×10^{-2}	4×10^{-8}	2×10^{-3}
Bismuth (83)	Bi 206	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
		I	1×10^{-7}	1×10^{-3}	5×10^{-9}	4×10^{-5}
	Bi 207	S	2×10^{-7}	2×10^{-3}	6×10^{-9}	6×10^{-5}
		I	1×10^{-8}	2×10^{-3}	5×10^{-10}	6×10^{-5}
	Bi 210	S	6×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}
		I	6×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}
	Bi 212	S	1×10^{-7}	1×10^{-2}	3×10^{-9}	4×10^{-4}
		I	2×10^{-7}	1×10^{-2}	7×10^{-9}	4×10^{-4}
Bromine (35)	Br 82	S	1×10^{-6}	8×10^{-3}	4×10^{-8}	3×10^{-4}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Cadmium (48)	Cd 109	S	5×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
		I	7×10^{-8}	5×10^{-3}	3×10^{-9}	2×10^{-4}
	Cd 115m	S	4×10^{-8}	7×10^{-4}	1×10^{-9}	3×10^{-5}
		I	4×10^{-8}	7×10^{-4}	1×10^{-9}	3×10^{-5}
	Cd 115	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Calcium (20)	Ca 45	S	3×10^{-8}	3×10^{-4}	1×10^{-9}	9×10^{-6}
		I	1×10^{-7}	5×10^{-3}	4×10^{-9}	2×10^{-4}
	Ca 47	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	3×10^{-5}
Californium (98)	Cf 249	S	2×10^{-12}	1×10^{-4}	5×10^{-14}	4×10^{-6}
		I	1×10^{-10}	7×10^{-4}	3×10^{-12}	2×10^{-5}
	Cf 250	S	5×10^{-12}	4×10^{-4}	2×10^{-13}	1×10^{-5}
		I	1×10^{-10}	7×10^{-4}	3×10^{-12}	3×10^{-5}
	Cf 251	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
	Cf 252	* S	6×10^{-12}	2×10^{-4}	2×10^{-13}	7×10^{-6}
		* I	3×10^{-11}	2×10^{-4}	1×10^{-12}	7×10^{-6}
	Cf 253	S	8×10^{-10}	4×10^{-3}	3×10^{-11}	1×10^{-4}
		I	8×10^{-10}	4×10^{-3}	3×10^{-11}	1×10^{-4}
	Cf 254	S	5×10^{-12}	4×10^{-6}	2×10^{-13}	1×10^{-7}
		I	5×10^{-12}	4×10^{-6}	2×10^{-13}	1×10^{-7}
Carbon (6)	C 14	S	4×10^{-6}	2×10^{-2}	1×10^{-7}	8×10^{-4}
	(CO_2)	Sub	5×10^{-3}		1×10^{-6}	
Cerium (58)	Ce 141	S	4×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	2×10^{-7}	3×10^{-3}	5×10^{-9}	9×10^{-5}
	Ce 143	S	3×10^{-7}	1×10^{-3}	9×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
	Ce 144	S	1×10^{-8}	3×10^{-4}	3×10^{-10}	1×10^{-5}
		I	6×10^{-9}	3×10^{-4}	2×10^{-10}	1×10^{-5}
Cesium (55)	Cs 131	S	1×10^{-5}	7×10^{-2}	4×10^{-7}	2×10^{-3}
		I	3×10^{-6}	3×10^{-2}	1×10^{-7}	9×10^{-4}
	Cs 134m	S	4×10^{-5}	2×10^{-1}	1×10^{-8}	6×10^{-3}
		I	6×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
	Cs 134	S	4×10^{-8}	3×10^{-4}	1×10^{-9}	9×10^{-6}
		I	1×10^{-8}	1×10^{-3}	4×10^{-10}	4×10^{-5}
	Cs 135	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	9×10^{-8}	7×10^{-3}	3×10^{-9}	2×10^{-4}
	Cs 136	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	9×10^{-5}
		I	2×10^{-7}	2×10^{-3}	6×10^{-9}	6×10^{-5}
	Cs 137	S	6×10^{-8}	4×10^{-4}	2×10^{-9}	2×10^{-5}
		I	1×10^{-8}	1×10^{-3}	5×10^{-10}	4×10^{-5}
Chlorine (17)	Cl 36	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
		I	2×10^{-8}	2×10^{-3}	8×10^{-10}	6×10^{-5}
	Cl 38	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	7×10^{-8}	4×10^{-4}
Chromium (24)	Cr 51	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	2×10^{-6}	5×10^{-2}	8×10^{-8}	2×10^{-3}

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

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

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

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

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Iodine (53)	I 134	I	3×10^{-6}	2×10^{-2}	$\times10^{-7}$	6×10^{-4}
	I 135	S	1×10^{-7}	7×10^{-4}	1×10^{-9}	4×10^{-6}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
Iridium (77)	Ir 190	S	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Ir 192	S	1×10^{-7}	1×10^{-3}	4×10^{-9}	4×10^{-5}
		I	3×10^{-8}	1×10^{-3}	9×10^{-10}	4×10^{-5}
	Ir 194	S	2×10^{-7}	1×10^{-2}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
Iron (26)	Fe 55	S	9×10^{-7}	2×10^{-2}	3×10^{-8}	8×10^{-4}
		I	1×10^{-6}	7×10^{-2}	3×10^{-8}	2×10^{-3}
	Fe 59	S	1×10^{-7}	2×10^{-3}	5×10^{-9}	6×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	5×10^{-5}
Krypton (36)	Kr 85m	Sub	6×10^{-6}		1×10^{-7}	
	Kr 85	Sub	1×10^{-5}		3×10^{-7}	
	Kr 87	Sub	1×10^{-6}		2×10^{-8}	
	Kr 88	Sub	1×10^{-6}		2×10^{-8}	
Lanthanum (57)	La 140	S	2×10^{-7}	7×10^{-4}	5×10^{-9}	2×10^{-5}
		I	1×10^{-7}	7×10^{-4}	4×10^{-9}	2×10^{-5}
Lead (82)	Pb 203	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	6×10^{-8}	4×10^{-4}
	Pb 210	S	1×10^{-10}	4×10^{-6}	4×10^{-12}	1×10^{-7}
		I	2×10^{-10}	5×10^{-3}	8×10^{-12}	2×10^{-4}
	Pb 212	S	2×10^{-8}	6×10^{-4}	6×10^{-10}	2×10^{-5}
		I	2×10^{-8}	5×10^{-4}	7×10^{-10}	2×10^{-5}
Lutetium (71)	Lu 177	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Manganese (25)	Mn 52	S	2×10^{-7}	1×10^{-3}	7×10^{-9}	3×10^{-5}
		I	1×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
	Mn 54	* S	4×10^{-7}	4×10^{-3}	1×10^{-8}	1×10^{-4}
		I	4×10^{-8}	3×10^{-3}	1×10^{-9}	1×10^{-4}
	Mn 56	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Mercury (80)	Hg 197m	S	7×10^{-7}	6×10^{-3}	3×10^{-8}	2×10^{-4}
		I	8×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Hg 197	S	1×10^{-6}	9×10^{-3}	4×10^{-8}	3×10^{-4}
		I	3×10^{-6}	1×10^{-2}	9×10^{-8}	5×10^{-4}
	Hg 203	S	7×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
Molybdenum (42)	Mo 99	S	7×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
Neodymium (60)	Nd 144	S	8×10^{-11}	2×10^{-3}	3×10^{-12}	7×10^{-5}
		I	3×10^{-10}	2×10^{-3}	1×10^{-11}	8×10^{-5}
	Nd 147	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	2×10^{-3}	8×10^{-9}	6×10^{-5}
	Nd 149	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-4}
		I	1×10^{-6}	8×10^{-3}	5×10^{-8}	3×10^{-4}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Neptunium (93)	Np 237	S	4×10^{-12}	9×10^{-5}	1×10^{-13}	3×10^{-6}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	Np 239	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	7×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
Nickel (28)	Ni 59	S	5×10^{-7}	6×10^{-3}	2×10^{-8}	2×10^{-4}
		I	8×10^{-7}	6×10^{-3}	3×10^{-8}	2×10^{-4}
	Ni 63	S	6×10^{-8}	8×10^{-4}	2×10^{-9}	3×10^{-5}
		I	3×10^{-7}	2×10^{-2}	1×10^{-8}	7×10^{-4}
	Ni 65	S	9×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Niobium (Columbium) (41)	Nb 93m	S	1×10^{-7}	1×10^{-2}	4×10^{-9}	4×10^{-4}
		I	2×10^{-7}	1×10^{-2}	5×10^{-9}	4×10^{-4}
	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}
	Nb 97	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
Osmium (76)	Os 185	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	7×10^{-5}
	Os 191m	S	2×10^{-5}	7×10^{-2}	6×10^{-7}	3×10^{-3}
		I	9×10^{-6}	7×10^{-2}	3×10^{-7}	2×10^{-3}
	Os 191	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	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^{-2}	5×10^{-8}	3×10^{-4}
		I	7×10^{-7}	8×10^{-3}	3×10^{-8}	3×10^{-4}
	Pd 109	S	6×10^{-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	8×10^{-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}	9×10^{-4}
		I	3×10^{-7}	5×10^{-2}	1×10^{-8}	2×10^{-3}
	Pt 197m	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
	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^{-4}	7×10^{-14}	5×10^{-6}
		I	3×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 239	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 240	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 241	S	9×10^{-11}	7×10^{-3}	3×10^{-12}	2×10^{-4}
		I	4×10^{-9}	4×10^{-2}	1×10^{-9}	1×10^{-3}

(1914) R Pt. 20

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

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

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

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

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Technetium (43)	Tc 96m	S	8×10^{-5}	4×10^{-1}	3×10^{-6}	1×10^{-2}
		I	3×10^{-5}	3×10^{-1}	1×10^{-6}	1×10^{-2}
	Tc 96	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Tc 97m	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	2×10^{-7}	5×10^{-3}	5×10^{-9}	2×10^{-4}
	Tc 97	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-4}
	Tc 99m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	6×10^{-3}
		I	1×10^{-5}	8×10^{-2}	5×10^{-7}	3×10^{-3}
	Tc 99	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	3×10^{-4}
		I	6×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
Tellurium (52)	Te 125m	S	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
	Te 127m	S	1×10^{-7}	2×10^{-3}	5×10^{-9}	6×10^{-5}
		I	4×10^{-8}	2×10^{-3}	1×10^{-9}	5×10^{-5}
	Te 127	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-4}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Te 129m	S	8×10^{-8}	1×10^{-3}	3×10^{-9}	3×10^{-5}
		I	3×10^{-8}	6×10^{-4}	1×10^{-9}	2×10^{-5}
	Te 129	S	5×10^{-6}	2×10^{-2}	2×10^{-7}	8×10^{-4}
		I	4×10^{-6}	2×10^{-2}	1×10^{-7}	1×10^{-4}
	Te 131m	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
	Te 132	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
Terbium (65)	Tb 160	S	1×10^{-7}	1×10^{-3}	3×10^{-9}	4×10^{-5}
		I	3×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
Thallium (81)	Tl 200	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	1×10^{-6}	7×10^{-3}	4×10^{-8}	2×10^{-4}
	Tl 201	S	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Tl 202	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	2×10^{-7}	2×10^{-3}	8×10^{-9}	7×10^{-5}
	Tl 204	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	3×10^{-8}	2×10^{-3}	9×10^{-10}	6×10^{-5}
Thorium (90)	Th 227	S	3×10^{-10}	5×10^{-4}	1×10^{-11}	2×10^{-5}
		I	2×10^{-10}	5×10^{-4}	6×10^{-12}	2×10^{-5}
	Th 228	S	9×10^{-12}	2×10^{-4}	3×10^{-13}	7×10^{-6}
		I	6×10^{-12}	4×10^{-4}	2×10^{-13}	1×10^{-5}
	Th 230	S	2×10^{-12}	5×10^{-5}	8×10^{-14}	2×10^{-6}
		I	1×10^{-11}	9×10^{-4}	3×10^{-13}	3×10^{-5}
	Th 231	S	1×10^{-6}	7×10^{-3}	5×10^{-8}	2×10^{-4}
		I	1×10^{-6}	7×10^{-3}	4×10^{-8}	2×10^{-4}
	Th 232	S	3×10^{-11}	5×10^{-5}	1×10^{-12}	2×10^{-6}
		I	3×10^{-11}	1×10^{-3}	1×10^{-12}	4×10^{-5}
	Th natural	S	6×10^{-11}	6×10^{-5}	2×10^{-12}	2×10^{-6}
		I	6×10^{-11}	6×10^{-4}	2×10^{-12}	2×10^{-5}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Thorium (90)	Th 234	S	6×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	3×10^{-8}	5×10^{-4}	1×10^{-9}	2×10^{-5}
Thulium (69)	Tm 170	S	4×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
		I	3×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
	Tm 171	S	1×10^{-7}	1×10^{-2}	4×10^{-9}	5×10^{-4}
		I	2×10^{-7}	1×10^{-2}	8×10^{-9}	5×10^{-4}
Tin (50)	Sn 113	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	9×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	8×10^{-5}
	Sn 125	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
		I	8×10^{-8}	5×10^{-4}	3×10^{-9}	2×10^{-5}
Tungsten (Wolfram) (74)	W 181	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	1×10^{-7}	1×10^{-2}	4×10^{-9}	3×10^{-4}
	W 185	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
	W 187	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
Uranium (92)	U 230	S	3×10^{-10}	1×10^{-4}	1×10^{-11}	5×10^{-6}
		I	1×10^{-10}	1×10^{-4}	4×10^{-12}	5×10^{-6}
	U 232	S	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
		I	3×10^{-11}	8×10^{-4}	9×10^{-13}	3×10^{-5}
	U 233	S	5×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
**	U 234	S[4]	6×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
**	U 235	S[4]	5×10^{-10}	8×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	U 236	S	6×10^{-10}	1×10^{-3}	2×10^{-11}	4×10^{-5}
		I	1×10^{-10}	1×10^{-3}	4×10^{-12}	3×10^{-5}
**	U 238	S[4]	7×10^{-11}	1×10^{-3}	3×10^{-12}	4×10^{-5}
		I	1×10^{-10}	1×10^{-3}	5×10^{-12}	4×10^{-5}
	U 240	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	3×10^{-5}
**	U-natural	S[4]	1×10^{-10}	1×10^{-3}	5×10^{-12}	3×10^{-5}
		I	1×10^{-10}	1×10^{-3}	5×10^{-12}	3×10^{-5}
Vanadium (23)	V 48	S	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
		I	6×10^{-8}	8×10^{-4}	2×10^{-9}	3×10^{-5}
Xenon (54)	Xe 131m	Sub	2×10^{-5}		4×10^{-7}	
	Xe 133	Sub	1×10^{-5}		3×10^{-7}	
	Xe 133m	Sub	1×10^{-5}		3×10^{-7}	
	Xe 135	Sub	4×10^{-6}		1×10^{-7}	
Ytterbium (70)	Yb 175	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Yttrium (39)	Y 90	S	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
		I	1×10^{-7}	6×10^{-4}	2×10^{-9}	2×10^{-5}
	Y 91m	S	2×10^{-5}	1×10^{-1}	8×10^{-7}	3×10^{-3}
		I	2×10^{-5}	1×10^{-1}	6×10^{-7}	3×10^{-3}
	Y 91	S	4×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
		I	3×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
	Y 92	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Y 93	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Zinc (30)	Zn 65	S	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
		I	6×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
	Zn 69m	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Zn 69	S	7×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-3}
		I	9×10^{-6}	5×10^{-2}	3×10^{-7}	2×10^{-3}
Zirconium (40)	Zr 93	S	1×10^{-7}	2×10^{-2}	4×10^{-9}	8×10^{-4}
		I	3×10^{-7}	2×10^{-2}	1×10^{-8}	8×10^{-4}
	Zr 95	S	1×10^{-7}	2×10^{-3}	4×10^{-9}	6×10^{-5}
		I	3×10^{-8}	2×10^{-3}	1×10^{-9}	6×10^{-5}
	Zr 97	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
		I	9×10^{-8}	5×10^{-4}	3×10^{-9}	2×10^{-5}
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours.		Sub	1×10^{-6}		3×10^{-8}	
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours.			3×10^{-9}	9×10^{-5}	1×10^{-10}	3×10^{-6}
Any single radionuclide not listed above, which decays by alpha emission or spontaneous fission.			6×10^{-12}	4×10^{-7}	2×10^{-14}	3×10^{-8}

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

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

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

40 FR 50704

‡4. For soluble mixtures of U-238, U-234 and U-235 in air chemical toxicity may be the limiting factor. If the percent by weight (enrichment) of U-235 is less than 5, the concentration value for a 40-hour workweek, Table I, is 0.2 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8×10^{-9} SA μCi-hr/ml, where SA is the specific activity of the uranium inhaled. The concentration value for Table II is 0.007 milligrams uranium per cubic meter of air. The specific activity for natural uranium is 6.77×10^{-7} curies per gram U. The specific activity for other mixtures of U-238, U-235 and U-234, if not known, shall be:

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

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

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

39 FR 23990

25 FR 10914

*Amended 37 FR 23319.

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

***Amended 40 FR 50704.

†Amended 38 FR 29314.

‡Amended 39 FR 25463, redesignated 40 FR 50704.

NOTE TO APPENDIX B

[25 FR 10914]

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

1. If the identity and concentration of each radionuclide in the mixture are known, the limiting values should be derived as follows: Determine, for each radionuclide in the mixture, the ratio between the quantity present in the mixture and the limit otherwise established in Appendix B for the specific radionuclide when not in a mixture. The sum of such ratios for all the radionuclides in the mixture may not exceed "1" (i.e., "unity").

EXAMPLE: If radionuclides A, B, and C are present in concentrations C_A, C_B, and C_C, and if the applicable MPC's, are MPC_A, and MPC_B, and MPC_C respectively, then the concentrations shall be limited so that the following relationship exists:

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

[30 FR 1580]

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

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

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

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

d. For purposes of Table II, Col. 2—3×10^{-8}

[26 FR 11046]

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

[30 FR 1580]

c. Element (atomic number) and isotope	Table I		Table II	
	Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)	Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
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 248, 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), Pb 210, Po 210, Ra 223, Ra 226, Ra 228, Pa 231, Th-nat, Cm 248, Cf 254, and Fm 256 are not present	.....	6×10^{-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^{-4}	.....	1×10^{-4}
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^{-12}	.....
If it is known that alpha-emitters and Pb 210, Ac 227, Ra 228, and Pu 241 are not present	3×10^{-12}	.....	1×10^{-11}	.....
If it is known that alpha-emitters and Ac 227 are not present	3×10^{-11}	.....	1×10^{-13}	.....
If it is known that Ac 227, Th 230, Pa 231, Pu 238, Pu 239, Pu 240, Pu 242, Pu 244, Cm 248, Cf 249 and Cf 251 are not present	3×10^{-13}	.....	1×10^{-13}	.....

[40 FR 50704]

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.

[39 FR 23990]

a. For purposes of Table I, Col. 1—1×10^{-10} μCi/ml gross alpha activity; or 5×10^{-11} μCi/ml natural uranium; or 75 micrograms per cubic meter of air natural uranium.

b. For purposes of Table II, Col. 1—3×10^{-12} μCi/ml gross alpha activity; or 2×10^{-12} μCi/ml natural uranium; or 3 micrograms per cubic meter of air natural uranium.

[26 FR 11046]

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

(i.e. $\frac{C_A}{MPC_A}+\frac{C_B}{MPC_B}+\ldots\ldots\leq 1/4$).

APPENDIX C

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

35 FR 6425

NOTE: For purposes of §§ 20.203 and 20.304, 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"). Example: For purposes of § 20.304, if a particular batch contains 20,000 μCi† of Au^{198} and 50,000 μCi† of C^{14}, it may also include not more than 300 μCi† of I^{131}. This limit was determined as follows:

† $\frac{20{,}000\ \mu Ci\ Au^{198}}{100{,}000\ \mu Ci} + \frac{50{,}000\ \mu Ci\ C^{14}}{100{,}000\ \mu Ci} + \frac{300\ \mu Ci\ I^{131}}{1{,}000\ \mu Ci} = 1$

The denominator in each of the above ratios was obtained by multiplying the figure in the table by 1,000 as provided in § 20.304.

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

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

* Amended 36 FR 16898.

** Amended 39 FR 23990.

† Amended 38 FR 29314.

Appendix D

UNITED STATES NUCLEAR REGULATORY COMMISSION

INSPECTION AND ENFORCEMENT REGIONAL OFFICES

Region	Address	Telephone	
		Daytime	Nights and Holidays
I Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont	Region I, USNRC Office of Inspection and Enforcement 631 Park Avenue King of Prussia, Pa. 19406	(215) 337-1150	(215) 337-1150
II Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, Panama Canal Zone, Puerto Rico, South Carolina, Tennessee, Virginia, Virgin Islands, and West Virginia	Region II, USNRC Office of Inspection and Enforcement 230 Peachtree St., N.W. Suite 1217 * Atlanta, Ga. 30303	* (404) 221-4503	* (404) 221-4503
III Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin	Region III, USNRC Office of Inspection and Enforcement 799 Roosevelt Road Glen Ellyn, Ill. 60137	(312) 858-2660	(312) 858-2660
IV Arkansas, Colorado, Idaho, Kansas, Louisiana, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, and Wyoming	Region IV, USNRC Office of Inspection and Enforcement 611 Ryan Plaza Drive Suite 1000 Arlington, Texas 76012	(817) 334-2841	(817) 334-2841
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40 FR 42557

*Amended 41 FR 55851.

November 1975
Revision 1

U.S. NUCLEAR REGULATORY COMMISSION

REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 8.13

INSTRUCTION CONCERNING PRENATAL RADIATION EXPOSURE

A. INTRODUCTION

Section 19.12 of 10 CFR Part 19 states that all individuals working in or frequenting any portion of a restricted area must be instructed in the health protection problems associated with exposure to radioactive materials or radiation. This guide describes the instruction that should be provided concerning biological risks to embryos or fetuses resulting from prenatal exposure.*

B. DISCUSSION

Since the Law of Bergonie and Tribondeau was published in 1906** it has been known that the sensitivity of cells to radiation damage is related to their reproductive activity and inversely related to their degree of differentiation. It follows that children could be expected to be more radiosensitive than adults, fetuses more radiosensitive than children, and embryos even more radiosensitive.

This principle has long been a factor in the development of radiation exposure standards. Section 20.104 of 10 CFR Part 20 places different limits on minors than on adult workers. Specifically, it limits anyone under the age of 18 to exposures not exceeding 10% of the limits for adult workers. However, §20.104 does not relate to embryos or fetuses.

A special situation arises when an occupationally exposed woman is pregnant. Exposure of the abdomen of such a worker to penetrating radiation from either external or internal sources would also involve exposure of the embryo or fetus. Because a number of studies have indicated that the embryo or fetus is more sensitive than an adult, particularly during the first three months after conception, when a woman may not be aware that she is pregnant, the National Council on Radiation Protection and Measurements (NCRP) recommended in its Report No. 39 that special precautions be taken to limit exposure when an occupationally exposed woman could be pregnant.

C. REGULATORY POSITION

Instruction to workers performed under §19.12 should be given prior to assignment to work in a restricted area. In providing instruction about health protection problems associated with radiation exposure, female workers and those who may supervise or work with them should be given specific instruction about prenatal exposure risks to the developing embryo and fetus.

The instruction should ensure that the employees understand:

1. That the NCRP has recommended that, during the entire gestation period, the maximum permissible dose equivalent to the fetus from occupational exposure of the expectant mother should not exceed 0.5 rem and

2. The reasons for this recommendation.

The instruction should include the information provided in the Appendix to this guide. It should be presented to the employee, her supervisors, and her co-workers both orally and in written form. Each individual should be given an opportunity to ask questions, and each individual should be asked to acknowledge in writing that the instruction has been received.

D. IMPLEMENTATION

The purpose of this section is to provide information to licensees regarding the use of this guide.

*This revision of the guide includes minor changes of a clarifying nature incorporated as a result of public comments. No substantive changes have been made.

**_Comptes Rendus des Seances de l'Academie des Sciences_, Vol. 143, pp. 983-985, 1906.

Except in those cases in which the licensee chooses to propose an alternative method for complying with the portion of the Commission's regulations previously specified, the methods described herein should be used immediately to instruct female employees working in or frequenting any portion of a restricted area, and those who may supervise or work with such employees, concerning the health protection problems associated with prenatal radiation exposure.

APPENDIX TO REGULATORY GUIDE 8.13

POSSIBLE HEALTH RISKS TO CHILDREN OF WOMEN WHO ARE EXPOSED TO RADIATION DURING PREGNANCY

Some recent studies have shown that the risk of leukemia and other cancers in children increases if the mother is exposed to a significant amount of radiation during pregnancy. According to a report by the National Academy of Sciences, the incidence of leukemia among children from birth to 10 years of age in the United States could rise from 3.7 cases in 10,000 children to 5.6 cases in 10,000 children if the children were exposed to 1 rem of radiation before birth (a "rem" is a measure of radiation). The Academy has also estimated that an equal number of other types of cancers could result from this level of radiation. Although other scientific studies have shown a much smaller effect from radiation, the Nuclear Regulatory Commission wants women employees of its licensees to be aware of any possible risk so that the women can take steps they think appropriate to protect their offspring.

As an employee of a Nuclear Regulatory Commission licensee, you may be exposed to more radiation than the general public. However, the Nuclear Regulatory Commission has established a basic exposure limit for all occupationally exposed adults of 1.25 rems per calendar quarter, or 5 rems per year. No clinical evidence of harm would be expected in an adult working within these levels for a lifetime. Because the risks of undesirable effects may be greater for young people, individuals under 18 years of age are permitted to be exposed to only 10 percent of the adult occupational limits. (This lower limit is also applied to members of the general public.)

The scientific organization called the National Council on Radiation Protection and Measurements has recommended that because unborn babies may be more sensitive to radiation than adults, their radiation dose as a result of occupational exposure of the mother should not exceed 0.5 rem. Other scientific groups, including the International Commission on Radiation Protection, have also stressed the need to keep radiation doses to unborn children as low as reasonably achievable.

All Nuclear Regulatory Commission licensees are now required* to inform all individuals who work in a restricted area of the health protection problems associated with radiation exposure. This instruction would in many cases include information on the possible risks to unborn babies. The regulations also state** that licensees should keep radiation exposures as low as is reasonably achievable. According to the National Council on Radiation Protection and Measurements, vigorous efforts should be made to keep the radiation exposure of an embryo or fetus at the very lowest practicable level during the entire period of pregnancy.

Thus it is the responsibility of your employer to take all practicable steps to reduce your radiation exposure. Then it is your responsibility to decide whether the exposure you are receiving is sufficiently low to protect your unborn child. The advice of your employer's health physicist or radiation protection officer should be obtained to determine whether radiation levels in your working areas are high enough that a baby could receive 0.5 rem or more before birth. If so, the alternatives that you might want to consider are:

(a) If you are now pregnant or expect to be soon, you could decide not to accept or continue assignments in these areas.

(b) You could reduce your exposure, where possible, by decreasing the amount of time you spend in the radiation area, increasing your distance from the radiation source, and using shielding.

(c) If you do become pregnant, you could ask your employer to reassign you to areas involving less exposure to radiation. If this is not possible, you might consider

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* By Title 10, Part 19 of the Code of Federal Regulations.

**In Title 10, Part 20.

leaving your job. If you decide to take such steps, do so without delay. The unborn child is most sensitive to radiation during the first three months of your pregnancy.

(d) You could delay having children until you are no longer working in an area where the radiation dose to your unborn baby could exceed 0.5 rem.

You may also, of course, choose to:

(e) Continue working in the higher radiation areas, but with full awareness that you are doing so at some small increased risk for your unborn child.

The following facts should be noted to help you make a decision:

1. The first three months of pregnancy are the most important, so you should make your decision quickly.

2. In most cases of occupational exposure, the actual dose received by the unborn baby is less than the dose received by the mother because some of the dose is absorbed by the mother's body.

3. At the present occupational exposure limit, the actual risk to the unborn baby is small, but experts disagree on the exact amount of risk.

4. There is no need to be concerned about sterility or loss of your ability to bear children. The radiation dose required to produce such effects is more than 100 times larger than the Nuclear Regulatory Commission's dose limits for adults.

5. Even if you work in an area where you receive only 0.5 rem per three-month period, in nine months you could receive 1.5 rems, and the unborn baby could receive more than 0.5 rem, the full-term limit suggested by the NCRP. Therefore, if you decide to restrict your unborn baby's exposure as recommended by the NCRP, be aware that the 0.5 rem limit to the unborn baby applies to the full nine-month pregnancy.

The remainder of this document contains a brief explanation of radiation and its effects on humans. As you will see, some radiation is present everywhere and the levels of radiation most employees of Nuclear Regulatory Commission licensees receive are not much larger than these natural levels. Because the radiation levels in the facility where you will be working are required by law to be kept quite low, there is not considered to be a significant health risk to individual adult employees.

Discussion of Radiation

The amount of radiation an individual receives is called the "dose" and is measured in "rems." The average individual in the United States accumulates a dose of one rem from natural sources every 12 years. The dose from natural radiation is higher in some states, such as Colorado, Wyoming, and South Dakota, primarily because of cosmic radiation. There the average individual gets one rem every 8 years.

Natural background radiation levels are also much higher in certain local areas. A dose of one rem may be received in some areas on the beach at Guarapari, Brazil, in only about 9 days, and some people in Kerala, India, get a dose of one rem every 5 months.

Many people receive additional radiation for medical reasons. In 1970, an estimated 212 million X-ray examinations were performed in the United States. The estimated average surface skin dose from one radiographic chest X-ray is 0.027 rem. The estimated average surface skin dose per abdominal X-ray is 0.62 rem.*

Radiation can also be received from natural sources such as rock or brick structures, from consumer products such as television and glow-in-the-dark watches, and from air travel. The possible annual dose from working 8 hours a day near a granite wall at the Redcap Stand in Grand Central Station, New York City, is 0.2 rem, and the average annual dose in the United States from TV, consumer products, and air travel is 0.0026 rem.

Radiation, like many things, can be harmful. A large dose to the whole body (such as 600 rems in one day) would probably cause death in about 30 days, but such large doses result only from rare accidents. Control of exposure to radiation is based on the assumption that any exposure, no matter how small, involves some risk. The occupational exposure limits are set so low, however, that medical evidence gathered over the past 50 years indicates no clinically observable injuries to individuals due to radiation exposures when the established radiation limits are not exceeded. This was true even for exposures received under the early occupational exposure limits, which were many times higher than the present limits. Thus the risk to individuals at the occupational exposure levels is considered to be very low. However, it is impossible to say that the risk is zero. To decrease the risk still further, licensees are expected to keep actual exposures as far below the limits as is reasonably achievable.

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*"Pre-Release Report: X-Ray Exposure Study (XES) Revised Estimates of 1964 and 1970 Genetically Significant Dose," February 4, 1975, U.S. Department of Health, Education, and Welfare, Public Health Service, Federal Drug Administration, Bureau of Radiological Health.

The current exposure limits for people working with radiation have been developed and carefully reviewed by nationally and internationally recognized groups of scientists. It must be remembered, however, that these limits are for adults. Special consideration is appropriate when the individual being exposed is, or may be, an expectant mother, because the exposure of an unborn child may also be involved.

Prenatal Irradiation

The prediction that an unborn child would be more sensitive to radiation than an adult is supported by observations for relatively large doses. Large doses delivered before birth alter both physical development and behavior in experimentally exposed animals. A report of the National Academy of Sciences states that short-term doses in the range of 10 to 20 rems cause subtle changes in the nerve cells of unborn and infant rats. The report also states, however, that no radiation induced changes in development have been demonstrated to result in experimental animals from doses up to about 1 rem per day extended over a large part of the period before birth.

The National Academy of Sciences also noted that doses of 25 to 50 rems to a pregnant human may cause growth disturbances in her offspring. Such doses substantially exceed, of course, the maximum permissible occupational exposure limits.

Concern about prenatal exposure (i.e., exposure of a child while in its mother's uterus) at the permissible occupational levels is primarily based on the possibility that cancer (especially leukemia) may develop during the first 10 years of the child's life. Several studies have been performed to evaluate this risk. One study involved the followup of 77,000 children exposed to radiation before birth (because of diagnostic abdominal X-rays made for medical purposes during their mother's pregnancy). Another study involved the followup of 20,000 such children. In addition, 1292 children who received prenatal exposure during the bombing of Hiroshima and Nagasaki were studied. Although contradictory results have been obtained, most of the evidence suggests a relationship between prenatal exposure and an increased risk of childhood cancer.

Summary

Occupational exposures to radiation are being kept low. However, qualified scientists have recommended that the radiation dose to an embryo or fetus as a result of occupational exposure of the expectant mother should not exceed 0.5 rem because of possible increased risk of childhood leukemia and cancer. Since this 0.5 rem is lower than the dose generally permitted to adult workers, women may want to take special actions to avoid receiving higher exposures, just as they might stop smoking during pregnancy or might climb stairs more carefully to reduce possible risks to their unborn children.

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5. U.S. Atomic Energy Commission, Division of Technical Information, Understanding the Atom Series:

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   The Genetic Effects of Radiation

   The Natural Radiation Environment

   Your Body and Radiation

APPENDIX H

Occupational Safety and Health Administration Standards

1910.96—IONIZING RADIATION

(a) Definitions applicable to this section.

(1) "Radiation" includes alpha rays, beta rays, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other atomic particles; but such term does not include sound or radio waves, or visible light, or infrared or ultraviolet light.

(2) "Radioactive material" means any material which emits, by spontaneous nuclear disintegration, corpuscular or electromagnetic emanations.

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

(4) "Unrestricted area" means any area access to which is not controlled by the employer for purposes of protection of individuals from exposure to radiation or radioactive materials.

(5) "Dose" means the quantity of ionizing radiation absorbed, per unit of mass, by the body or by any portion of the body. When the provisions in this section specify a dose during a period of time, the dose is 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 used in this section are set forth in subparagraphs (6) and (7) of this paragraph.

(6) "Rad" means a measure of the dose of any ionizing radiation to body tissues in terms of the energy absorbed per unit of mass of the tissue. One rad is the dose corresponding to the absorption of 100 ergs per gram of tissue (1 millirad (mrad) = 0.001 rad).

(7) "Rem" means a measure of the dose of any ionizing radiation to body tissue in terms of its estimated biological effect relative to a dose of 1 roentgen (r) of X-rays (1 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 for irradiation. Each of the following is considered to be equivalent to a dose of 1 rem:

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

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

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

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

(v) If it is more convenient to measure the neutron flux, or equivalent, than to determine the neutron dose in rads, as provided in subdivision (iii) of this subparagraph, 1 rem of neutron radiation may, for purposes of the provisions in this section be assumed to be equivalent to 14 million neutrons per square centimeter incident upon the body; or, if there is 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 1 rem may be estimated from Table G–17:

TABLE G-17—NEUTRON FLUX DOSE EQUIVALENTS

Neutron energy (million electron volts (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 per sec.)
Thermal	970 × 10⁶	670
0.0001	720 × 10⁶	500
0.005	820 × 10⁶	570
0.02	400 × 10⁶	280
0.1	120 × 10⁶	80
0.5	43 × 10⁶	30
1.0	26 × 10⁶	18
2.5	29 × 10⁶	20
5.0	26 × 10⁶	18
7.5	24 × 10⁶	17
10	24 × 10⁶	17
10 to 30	14 × 10⁶	10

(8) For determining exposures to X- or gamma rays up to 3 Mev., the dose limits specified in this section may be assumed to be equivalent to the "air dose." For the purpose of this section "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 the highest dosage rate.

(b) Exposure of individuals to radiation in restricted areas.

(1) Except as provided in subparagraph (2) of this paragraph, no employer shall possess, use, or transfer sources of ionizing radiation in such a manner as to cause any individual in a restricted area to receive in any period of one calendar quarter from sources in the employer's possession or control a dose in excess of the limits specified in Table G-18:

TABLE G-18

	Rems per calendar quarter
Whole body: Head and trunk; active blood-forming organs; lens of eyes; or gonads	1¼
Hands and forearms; feet and ankles	18¾
Skin of whole body	7½

(2) An employer may permit an individual in a restricted area to receive doses to the whole body greater than those permitted under subparagraph (1) of this paragraph, so long as:

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

(ii) 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

(iii) The employer maintains adequate past and current exposure records which show that the addition of such a dose will not cause the individual to exceed the amount authorized in this subparagraph. As used in this subparagraph, "dose to the whole body" shall be deemed to include any dose to the whole body, gonad, active bloodforming organs, head and trunk, or lens of the eye.

(3) No employer shall permit any employee who is under 18 years of age to receive in any period of one calendar quarter a dose in excess of 10 percent of the limits specified in Table G–18.

(4) "Calendar quarter" means any 3-month period determined as follows:

(i) The first period of any year may begin on any date in January: *Provided*, That the second, third, and fourth periods accordingly begin on the same date in April, July, and October, respectively, and that the fourth period extends into January of the succeeding year, if necessary to complete a 3-month quarter. During the first year of use of this method of determination, the first period for that year shall also include any additional days in January preceding the starting date for the first period; or

(ii) The first period in a calendar year of 13 complete, consecutive calendar weeks; the second period in a calendar year of 13 complete consecutive weeks; the third period in a calendar year of 13 complete,

consecutive calendar weeks; the fourth period in a calendar year of 13 complete, consecutive calendar weeks. If at the end of a calendar year there are any days not falling within a complete calendar week of that year, such days shall be included within the last complete calendar week of that year. If at the beginning of any calendar year there are days not falling within a complete calendar week of that year, such days shall be included within the last complete calendar week of the previous year; or

(iii) The four periods in a calendar year may consist of the first 14 complete, consecutive calendar weeks; the next 12 complete, consecutive calendar weeks, the next 14 complete, consecutive calendar weeks, and the last 12 complete, consecutive calendar weeks. If at the end of a calendar year there are any days not falling within a complete calendar week of that year, such days shall be included (for purposes of this section) within the last complete calendar week of the year. If at the beginning of any calendar year there are days not falling within a complete calendar week of that year, such days shall be included (for purposes of this section) within the last complete week of the previous year.

(5) No employer shall change the method used by him to determine calendar quarters except at the beginning of a calendar year.

(c) Exposure to airborne radioactive material.

(1) No employer shall possess, use or transport radioactive material in such a manner as to cause any employee, within a restricted area, to be exposed to airborne radioactive material in an average concentration in excess of the limits specified in Table 1 of Appendix B to 10 CFR Part 20. The limits given in Table 1 are for exposure to the concentrations specified for 40 hours in any workweek of 7 consecutive days. In any such period where the number of hours of exposure is less than 40, the limits specified in the table may be increased proportionately. In any such period where the number of hours of exposure is greater than 40, the limits specified in the table shall be decreased proportionately.

(2) No employer shall possess, use, or transfer radioactive 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 in an average concentration in excess of the limits specified in Table II of Appendix B to 10 CFR Part 20. For purposes of this subparagraph, concentrations may be averaged over periods not greater than 1 week.

(3) "Exposed" as used in this paragraph means that the individual is present in an airborne concentration. No allowance shall be made for the use of protective clothing or equipment, or particle size.

(d) Precautionary procedures and personal monitoring.

(1) Every employer shall make such surveys as may be necessary for him to comply with the provisions in this section. "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.

(2) Every employer shall supply appropriate personnel monitoring equipment, such as film badges, pocket chambers, pocket dosimeters, or film rings, to, and shall require the use of such equipment by:

(i) Each employee 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 (b)(1) of this section; and

(ii) Each employee 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 (b)(1) of this section; and

(iii) Each employee who enters a high radiation area.

(3) As used in this section:

(i) "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.);

(ii) "Radiation area" means any area, accessible to personnel, in which there exists radiation at such levels that a major portion of the body could receive in any 1 hour a dose in excess of 5 millirem, or in any 5 consecutive days a dose in excess of 100 millirem; and

(iii) "High radiation area" means any area, accessible to personnel, in which there exists radiation at such levels that a major portion of the body could receive in any one hour a dose in excess of 100 millirem.

(e) Caution signs, labels, and signals.

(1) General.

(i) Symbols prescribed by this paragraph shall use the conventional radiation caution colors (magenta or purple on yellow background). The symbol prescribed by this paragraph is the conventional three-bladed design:

RADIATION SYMBOL

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

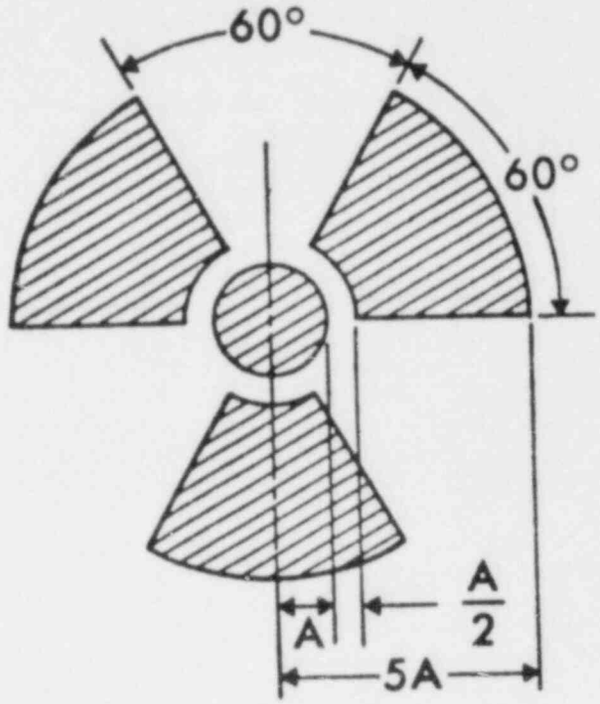

FIGURE G–10

(ii) In addition to the contents of signs and labels prescribed in this paragraph, employers 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.

(2) Radiation area. Each radiation area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol described in subparagraph (1) of this paragraph and the words:

CAUTION
RADIATION AREA

(3) High radiation area.

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

CAUTION
HIGH RADIATION AREA

(ii) Each high radiation area shall be

equipped with a control device which shall either cause the level of radiation to be reduced below that at which an individual might receive a dose of 100 millirems in 1 hour upon entry into the area or shall energize a conspicuous visible or audible alarm signal in such a manner that the individual entering and the employer or a supervisor of the activity are made aware of the entry. In the case of a high radiation area established for a period of 30 days or less, such control device is not required.

(4) Airborne radioactivity area.

(i) As used in the provisions of this section, "airborne radioactivity area" means:

(a) Any room, enclosure, or operating area in which airborne radioactive materials, composed wholly or partly of radioactive material, exist in concentrations in excess of the amounts specified in column 1 of Table 1 of Appendix B to 10 CFR Part 20 or

(b) Any room, enclosure, or operating area in which airborne radioactive materials exist 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 column 1 of Table 1 of Appendix B to 10 CFR Part 20.

(ii) Each airborne radioactivity area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol described in subparagraph (1) of this paragraph and the words:

CAUTION
AIRBORNE RADIOACTIVITY AREA

(5) Additional requirements.

(i) Each area or room in which radioactive material is used or stored and which contains any radioactive material (other than natural uranium or thorium) in any amount exceeding 10 times the quantity of such material specified in Appendix C to 10 CFR Part 20 shall be conspicuously posted with a sign or signs bearing the radiation caution symbol described in subparagraph (1) of this paragraph and the words:

CAUTION
RADIOACTIVE MATERIALS

(ii) Each area or room in which natural uranium or thorium is used or stored in an amount exceeding 100 times the quantity of such material specified in 10 CFR Part 20 shall be conspicuously posted with a sign or signs bearing the radiation caution symbol described in subparagraph (1) of this paragraph and the words:

CAUTION
RADIOACTIVE MATERIALS

(6) Containers.

(i) Each container in which is transported, stored, or used a quantity of any radioactive material (other than natural uranium or thorium) greater than the quantity of such material specified in Appendix C to 10 CFR Part 20 shall bear a durable, clearly visible label bearing the radiation caution symbol described in subparagraph (1) of this paragraph and the words:

CAUTION
RADIOACTIVE MATERIALS

(ii) Each container in which natural uranium or thorium is transported, stored, or used in a quantity greater than 10 times the quantity specified in Appendix C to 10 CFR Part 20 shall bear a durable, clearly visible label bearing the radiation caution symbol described in subparagraph (1) of this paragraph and the words:

CAUTION
RADIOACTIVE MATERIALS

(iii) Notwithstanding the provisions of subdivisions (i) and (ii) of this subparagraph a label shall not be required:

(a) If the concentration of the material in the container does not exceed that

specified in column 2 of Table 1 of Appendix B to 10 CFR Part 20, or

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

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

(f) Immediate evacuation warning signal.

(1) Signal characteristics.

(i) The signal shall be a midfrequency complex sound wave amplitude modulated at a subsonic frequency. The complex sound wave in free space shall have a fundamental frequency (f_1) between 450 and 500 hertz (Hz) modulated at a subsonic rate between 4 and 5 hertz.

(ii) The signal generator shall not be less than 75 decibels at every location where an individual may be present whose immediate, rapid, and complete evacuation is essential.

(iii) A sufficient number of signal units shall be installed such that the requirements of subdivision (ii) of this subparagraph are met at every location where an individual may be present whose immediate, rapid, and complete evacuation is essential.

(iv) The signal shall be unique in the plant or facility in which it is installed.

(v) The minimum duration of the signal shall be sufficient to insure that all affected persons hear the signal.

(vi) The signal-generating system shall respond automatically to an initiating event without requiring any human action to sound the signal.

(2) Design objectives.

(i) The signal-generating system shall be designed to incorporate components which enable the system to produce the desired signal each time it is activated within one-half second of activation.

(ii) The signal-generating system shall be provided with an automatically activated secondary power supply which is adequate to simultaneously power all emergency equipment to which it is connected, if operation during power failure is necessary, except in those systems using batteries as the primary source of power.

(iii) All components of the signal-generating system shall be located to provide maximum practicable protection against damage in case of fire, explosion, corrosive atmosphere, or other environmental extremes consistent with adequate system performance.

(iv) The signal-generating system shall be designed with the minimum number of components necessary to make it function as intended, and should utilize components which do not require frequent servicing such as lubrication or cleaning.

(v) Where several activating devices feed activating information to a central signal generator, failure of any activating device shall not render the signal-generator system inoperable to activating information from the remaining devices.

(vi) The signal-generating system shall be designed to enhance the probability that alarm occurs only when immediate evacuation is warranted. The number of false alarms shall not be so great that the signal will come to be disregarded and shall be low enough to minimize personal injuries or excessive property damage that might result from such evacuation.

(3) Testing.

(i) Initial tests, inspections, and checks of the signal-generating system shall be made to verify that the fabrication and

installation were made in accordance with design plans and specifications and to develop a thorough knowledge of the performance of the system and all components under normal and hostile conditions.

(ii) Once the system has been placed in service, periodic tests, inspections, and checks shall be made to minimize the possibility of malfunction.

(iii) Following significant alterations or revisions to the system, tests and checks similar to the initial installation tests shall be made.

(iv) Tests shall be designed to minimize hazards while conducting the tests.

(v) Prior to normal operation the signal-generating system shall be checked physically and functionally to assure reliability and to demonstrate accuracy and performance. Specific tests shall include:

(a) All power sources.

(b) Calibration and calibration stability.

(c) Trip levels and stability.

(d) Continuity of function with loss and return of required services such as AC or DC power, air pressure, etc.

(e) All indicators.

(f) Trouble indicator circuits and signals, where used.

(g) Air pressure (if used).

(h) Determine that sound level of the signal is within the limit of subparagraph (1)(ii) of this paragraph at all points that require immediate evacuation.

(vi) In addition to the initial startup and operating tests, periodic scheduled performance tests and status checks must be made to insure that the system is at all times operating within design limits and capable of the required response. Specific periodic tests or checks or both shall include:

(a) Adequacy of signal activation device.

(b) All power sources.

(c) Function of all alarm circuits and trouble indicator circuits including trip levels.

(d) Air pressure (if used).

(e) Function of entire system including operation without power where required.

(f) Complete operational tests including sounding of the signal and determination that sound levels are adequate.

(vii) Periodic tests shall be scheduled on the basis of need, experience, difficulty, and disruption of operations. The entire system should be operationally tested at least quarterly.

(viii) All employees whose work may necessitate their presence in an area covered by the signal shall be made familiar with the actual sound of the signal—preferably as it sounds at their work location. Before placing the system into operation, all employees normally working in the area shall be made acquainted with the signal by actual demonstration at their work locations.

(g) Exceptions from posting requirements.

Notwithstanding the provisions of paragraph (e) of this section:

(1) 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 12 inches from the surface of the source container or housing does not exceed 5 millirem per hour.

(2) Rooms or other areas in onsite medical facilities are not required to be posted with

caution signs because of the presence of patients containing radioactive material, provided that there are personnel in attendance who shall take the precautions necessary to prevent the exposure of any individual to radiation or radioactive material in excess of the limits established in the provisions of this section.

(3) Caution signs are not required to be posted at areas or rooms containing radioactive materials for periods of less than 8 hours: *Provided*, That

(i) 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 provisions of this section; and

(ii) Such area or room is subject to the employer's control.

(h) Exemptions for radioactive materials packaged for shipment.

Radioactive materials packaged and labeled in accordance with regulations of the Department of Transportation published in 49 CFR Chapter I, are exempt from the labeling and posting requirements of this subpart during shipment, provided that the inside containers are labeled in accordance with the provisions of paragraph (e) of this section.

(i) Instruction of personnel, posting.

(1) Employers regulated by the Atomic Energy Commission shall be governed by 10 CFR Part 20 standards. Employers in a State named in paragraph (p)(3) of this section shall be governed by the requirements of the laws and regulations of that State. All other employers shall be regulated by the following:

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

(3) Each employer to whom this section applies shall post a current copy of its provisions and a copy of the operating procedures applicable to the work conspicuously in such locations as to insure that employees working in or frequenting radiation areas will observe these documents on the way to and from their place of employment, or shall keep such documents available for examination of employees upon request.

(j) Storage of radioactive materials.

Radioactive materials stored in a nonradiation area shall be secured against unauthorized removal from the place of storage.

(k) Waste disposal.

No employer shall dispose of radioactive material except by transfer to an authorized recipient, or in a manner approved by the Atomic Energy Commission or a State named in paragraph (p)(3) of this section.

(l) Notification of incidents.

(1) **Immediate notification.** Each employer shall immediately notify the Assistant Secretary of Labor or his duly authorized representative, for employees not protected by the Atomic Energy Commission by means of 10 CFR Part 20; paragraph (p)(2) of this section, or the requirements of the laws and regulations of States named in paragraph (p)(3) of this section, by telephone or telegraph of any incident involving radiation which may have caused or threatens to cause:

(i) 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 to 150 rems or more of radiation; or exposure of the feet, ankles, hands, or forearms of any individual to 375 rems or more of radiation; or

(ii) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 5,000 times the limit specified for such materials in Table II of Appendix B to 10 CFR Part 20.

(iii) A loss of 1 working week or more of the operation of any facilities affected; or

(iv) Damage to property in excess of $100,000.

(2) **Twenty-four hour notification.** Each employer shall within 24 hours following its occurrence notify the Assistant Secretary of Labor or his duly authorized representative for employees not protected by the Atomic Energy Commission by means of 10 CFR Part 20; paragraph (p)(2) of this section, or the requirements of the laws and applicable regulations of States named in paragraph (p)(3) of this section, by telephone or telegraph of any incident involving radiation which may have caused or threatens to cause:

(i) 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

(ii) A loss of 1 day or more of the operation of any facilities; or

(iii) Damage to property in excess of $10,000.

(m) Reports of overexposure and excessive levels and concentrations.

(1) In addition to any notification required by paragraph (1) of this section each employer shall make a report in writing within 30 days to the Assistant Secretary of Labor or his duly authorized representative, for employees not protected by the Atomic Energy Commission by means of 10 CFR Part 20; or under paragraph (p)(2) of this section, or the requirements of the laws and regulations of States named in paragraph (p)(3) of this section, of each exposure of an individual to radiation or concentrations of radioactive material in excess of any applicable limit in this section. Each report required under this subparagraph shall describe the extent of exposure of persons to radiation or to radioactive material; levels of radiation and concentration of radioactive material involved, the cause of the exposure, levels of concentrations; and corrective steps taken or planned to assure against a recurrence.

(2) In any case where an employer is required pursuant to the provisions of this paragraph to report to the U.S. Department of Labor any exposure of an individual to radiation or to concentrations of radioactive material, the employer shall also notify such individual of the nature and extent of exposure. Such notice shall be in writing and shall contain the following statement: "You should preserve this report for future reference."

(n) Records.

(1) Every employer shall maintain records of the radiation exposure of all employees for whom personnel monitoring is required under paragraph (d) of this section and advise each of his employees of his individual exposure on at least an annual basis.

(2) Every employer shall maintain records in the same units used in tables in paragraph (b) of this section and Appendix B to 10 CFR Part 20.

(o) Disclosure to former employee of individual employee's record.

(1) At the request of a former employee an employer shall furnish to the employee a report of the employee's exposure to radiation as shown in records maintained by the employer pursuant to paragraph (n)(1) of this section. Such report shall be furnished within 30 days from the time the request

is made, and shall cover each calendar quarter of the individual's employment involving exposure to radiation or such lesser period as may be requested by the employee. The report shall also include the results of any calculations and analysis of radioactive material deposited in the body of the employee. The report shall be in writing and contain the following statement: "You should preserve this report for future reference."

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

(p) Atomic Energy Commission licensees—AEC contractors operating AEC plants and facilities—AEC agreement State licensees or registrants.

(1) Any employer who possesses or uses source material, byproduct material, or special nuclear material, as defined in the Atomic Energy Act of 1954, as amended, under a license issued by the Atomic Energy Commission and in accordance with the requirements of 10 CFR Part 20 shall be deemed to be in compliance with the requirements of this section with respect to such possession and use.

(2) AEC contractors operating AEC plants and facilities: Any employer who possesses or uses source material, byproduct material, special nuclear material, or other radiation sources under a contract with the Atomic Energy Commission for the operation of AEC plants and facilities and in accordance with the standards, procedures, and other requirements for radiation protection established by the Commission for such contract pursuant to the Atomic Energy Act of 1954 as amended (42 U.S.C. 2011 et seq.), shall be deemed to be in compliance with the requirements of this section with respect to such possession and use.

(3) AEC-agreement State licensees or registrants:

(i) **Atomic Energy Act sources.** Any employer who possesses or uses source material, byproduct material, or special nuclear material, as defined in the Atomic Energy Act of 1954, as amended (42 U.S.C. 2011 et seq.), and has either registered such sources with, or is operating under a license issued by, a State which has an agreement in effect with the Atomic Energy Commission pursuant to section 274(b) (42 U.S.C. 2021(b)) of the Atomic Energy Act of 1954, as amended, and in accordance with the requirements of that State's laws and regulations shall be deemed to be in compliance with the radiation requirements of this section, insofar as his possession and use of such material is concerned, unless the Secretary of Labor, after conference with the Atomic Energy Commission, shall determine that the State's program for control of these radiation sources is incompatible with the requirements of this section. Such agreements currently are in effect only in the States of Alabama, Arkansas, California, Kansas, Kentucky, Florida, Mississippi, New Hampshire, New York, North Carolina, Texas, Tennessee, Oregon, Idaho, Arizona, Colorado, Louisiana, Nebraska, Washington, Maryland, North Dakota, South Carolina, and Georgia.

(ii) **Other sources.** Any employer who possesses or uses radiation sources other than source material, byproduct material, or special nuclear material, as defined in the Atomic Energy Act of 1954, as amended (42 U.S.C. 2011 et seq.), and has either registered such sources with, or is operating under a license issued by a State which has an agreement in effect with the Atomic Energy Commission pursuant to section 274(b) (42 U.S.C. 2021(b)) of the Atomic Energy Act of 1954, as amended, and in accordance with the requirements of that State's laws and regulations shall be deemed to be in compliance with the radiation requirements of this section, insofar as his possession and use of such material is concerned, provided the State's program for control of these radiation sources is the subject of a currently effective determination by the Assistant Secretary of Labor that such program is compatible with the requirements of this section. Such determinations currently are in effect only in the States of Alabama, Arkansas, California, Kansas, Kentucky, Florida,

Mississippi, New Hampshire, New York, North Carolina, Texas, Tennessee, Oregon, Idaho, Arizona, Colorado, Louisiana, Nebraska, Washington, Maryland, North Dakota, South Carolina, and Georgia.

(q) [Reserved]

(r) Radiation standards for mining.

(1) For the purpose of this paragraph, a "working level" is defined as any combination of radon daughters in 1 liter of air which will result in the ultimate emission of 1.3×10^5 million electron volts of potential alpha energy. The numerical value of the "working level" is derived from the alpha energy released by the total decay of short-lived radon daughter products in equilibrium with 100 picocuries of radon 222 per liter of air. A working level month is defined as the exposure received by a worker breathing air at one working level concentration for 4⅓ weeks of 40 hours each.

(2) Occupational exposure to radon daughters in mines shall be controlled so that no individual will receive an exposure of more than 2 working level months in any calendar quarter and no more than 4 working level months in any calendar year. Actual exposures shall be kept as far below these values as practicable.

(3)

(i) For uranium mines, records of environmental concentrations in the occupied parts of the mine, and of the time spent in each area by each person involved in an underground work shall be established and maintained. These records shall be in sufficient detail to permit calculations of the exposures, in units of working level months, of the individuals and shall be available for inspection by the Secretary of Labor or his authorized agents.

(ii) For other than uranium mines and for surface workers in all mines, subdivision (i) of this subparagraph will be applicable: *Provided, however,* That if no environmental sample shows a concentration greater than 0.33 working level in any occupied part of the mine, the maintenance of individual occupancy records and the calculation of individual exposures will not be required.

(4)

(i) At the request of an employee (or former employee) a report of the employee's exposure to radiation as shown in records maintained by the employer pursuant to subparagraph (3) of this paragraph, shall be furnished to him. The report shall be in writing and contain the following statement:

This report is furnished to you under the provisions of the U.S. Department of Labor, Ionizing Radiation Safety and Health Standards (29 CFR 1910.96(r)). You should preserve this report for future reference.

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

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