RADIOISOTOPE GUIDELINES MANUAL

Forward
to
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This Radioisotope Guidelines Manual has been prepared by the Corporate Radiological Control Officer of Miles Laboratories, Inc., and is issued by the Radioisotope Committee.

The Radiological Control Office is located in Corporate Safety and Health, Building 2, Floor 1, phone extension 7574.

EMERGENCY PHONE NUMBERS

In case of radioactive accident, spill, or related contamination problems, call:

Radiological Control Officer 7574
or
Security (who will locate appropriate personnel) . . . 8400

ADMINISTRATION

MILES LABORATORIES, INC. - RADIOISOTOPE COMMITTEE

Kenyon D. Yoder, Chairman and Corp. Radiological Control Officer
Jim Mitchell, Buyer, Lab Supplies and Equipment
John H. Engelmann, Ph.D., J.D., Assistant Counsel
Marshall L. Fader, Supervisor, Ames Lab Facilities & Services
William A. Himmelsbach, M.D., Director, Employee Medical Affairs

AREA RADIOLOGICAL CONTROL SUPERVISORS (A.R.C.S.)

Location	Restricted Area Department	Area Supervisor
Bldg. 9, W2	Ames Immunochemistry R&D	Robert J. Carrico, Ph.D.
Bldg. 9, W1	Central Research Services	Jerry L. Leeling, Ph.D.
Bldg. 9, W1	Biotechnology-Chemistry	Clifford O. Yehle, Ph.D.
Bldg. 17	Biotechnology-Biology	Josephine C. Grosch, Ph.D.
Bldg. 18B, 2	Ames Product Evaluation	Jim Dugle
Bldg. 18, B	Ames Urine Chemistry	Alan Burkhardt, Ph.D.
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South Bend	Ames Liquid Reagents QA & Dist. Warehouse	Larry Craigo
Lisle, Ill.	Miles Scientific	Leslie Sudbury

RADIOISOTOPE GUIDELINES MANUAL

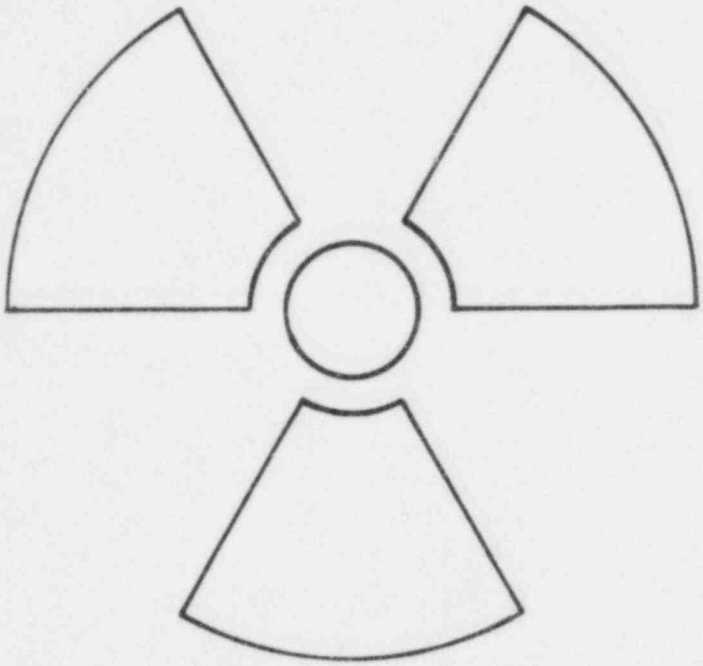
Introduction

Miles Laboratories, Inc., a corporation headquartered in Indiana, holds a broad scope radioactive materials license for the acquisition, possession, use and transfer of radioactive material. Authorized uses include research and development and processing for commercial distribution. A separate specific license authorizes Miles Laboratories to distribute Iodine-125 *in vitro* diagnostic radioimmunoassay reagents or test systems to physicians, veterinarians in the practice of veterinary medicine, clinical laboratories or hospitals who hold a proper license. A third separate specific license authorizes Miles Laboratories to distribute radioactive material, in the form of counting standards for our laboratory gamma counting instruments, to persons exempt from licensing. Additional licenses are held by domestic plants of Miles located outside of Indiana. The licenses held by the Elkhart facility are issued with the condition that the licensee shall comply in full with the provision of the U.S. Nuclear Regulatory Commission, which require in part that the licensee meet the following conditions: 1) establish a Radiation Safety Committee, 2) appoint a Radiation Safety Officer, and 3) establish appropriate administrative procedures to assure compliance with all requirements. In the course of this manual, the duties and responsibilities of committee members and the Radiation Safety Officer, as well as the duties and responsibilities of individual radioisotope users, are clearly defined and described.

The purpose of this manual is to set forth practices and procedures that will ensure the safety of the employee, the public, and the environment. It is meant to help the radioisotope users' work proceed with ease and with a minimum of inconvenience while guarding their safety and well-being.

For those with no formal training in the physical sciences, a glossary is included that contains all basic or fundamental expressions, units, or definitions. Copies of all forms that may be referenced in the handbook are also included for illustration. This manual is required to be read by anyone intending to use radioactive material in the course of employment by Miles Laboratories, Inc.

RADIOLOGICAL CONTROL HANDBOOK



Miles Laboratories, Inc.
Elkhart, Indiana
October, 1981

RADIOLOGICAL CONTROL HANDBOOK

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Chapter I: ISOTOPE COMMITTEE

A. Responsibilities and Authority of the Committee

1. Establish policies, procedures, and guidelines for the control of isotopes consistent with the regulation and license conditions.
2. Review and grant permission for, or disapprove, the use of radioactive isotopes within the company from the standpoint of safety and scientific validity.
3. Review and approve adequacy of procedures, equipment, and facilities from a safety and health viewpoint to be employed in the use of radioactive materials. Committee approval of safety measures must be obtained before initiation of new projects.
4. Review and approve adequacy of training and experience of all applicants requesting permission to obtain and use radioactive materials.
5. Prepare and distribute information on radiological safety.
6. Keep records concerning action taken regarding application for radioisotope usage and other operations submitted to the committee, and maintain record of committee meeting proceedings.

B. Committee meets four times yearly (the 3rd or 4th week following each physical quarter) and at such other times as may be deemed necessary.

1. A quorum shall consist of the Chairperson or Radiological Control Officer and two other members. If both Chairman and RCO are present, one may qualify as one of the members.
2. The Radiological Control Officer is authorized to act for the committee between meetings reporting such actions to the committee for review at appropriate intervals.

Chapter II: RADIOLOGICAL CONTROL OFFICER

A. Serve as liaison between Miles Laboratories, Inc., and the Nuclear Regulatory Commission.

B. Prepare and maintain all Nuclear Regulatory Commission Licenses, amendments, and renewals for facilities in the state of Indiana and assist all domestic plants.

C. Control the requisitioning, receiving, storing, processing, disposing, and transferring of all radioisotopes, including records of same.

D. Review all proposals for the use of isotopes.

E. Provide assistance and counsel in facility planning, design, and construction of all new areas or facilities using isotopes.

F. Conduct a continuous program of radiation hazard evaluation and elimination.

G. Maintain a continuous program of radiation surveys and monitoring of all isotope facilities, and records of same.

H. Maintain a personnel monitoring program, including bioassay when required. Maintain personnel records and notify individuals of their exposure.

I. Supervise and coordinate the waste disposal program, including storage and disposal; and maintain records as specified by the applicable regulatory agency.

J. Maintain and calibrate all health physics instrumentation, materials, and supplies. Disseminate information on all aspects of radiation protection.

K. Supervise and assist with decontamination in case of accidental spills involving radioactive materials.

L. Provide counsel in the manufacture, packaging, and distribution of commercial products containing radioactive material.

M. Overall administrative direction of the company radiation safety program to ensure compliance with state and federal regulations and license conditions.

Chapter III: AREA RADIOLOGICAL CONTROL SUPERVISOR

A. An individual, of exempt level status, in each isotope using laboratory shall, at the request of the Radiological Control Officer (RCO), be designated by the laboratory director. This individual shall be referred to as the Area Radiological Control Supervisor (ARCS).

B. Personnel

1. Responsible for the use of radioactive materials within his/her department or laboratory area.
2. Must insure that each person under his/her direction uses safe handling procedures and appropriate protective equipment to assure the safety of all personnel.
3. Request all personnel to use film badges or other personnel monitoring equipment when appropriate.
4. Restrict use of isotopes to the posted areas designated for radioactive materials.
5. Report any accidental inhalation, ingestion, or injury involving radioactive materials to the RCO and to the Medical Department.
6. Assure that all workers receive direct supervision and on-the-job training in the use of radioactive materials for a period of at least 6 months.
7. Quarterly provide RCO a list of current personnel using isotopes.

C. Area Surveys

1. Responsible to establish appropriate procedures for contamination surveys and insure that the surveys are conducted at monthly intervals.
2. Survey records must be forwarded promptly to RCO.

D. Purchase of Isotopes

1. Submit a "Protocol for the use of Radioactive Materials" for proposed projects including information on procedures, methods, and safety equipment and facilities to the RCO.
2. Send Purchase Requisition and Isotope Procurement Form #4.090, signed by ARCS, to the RCO.
3. Maintain current inventories of isotopes in his/her possession and submit a quarterly report to the RCO.

E. Waste Disposal

1. Forward all waste, accompanied by a completed Form #4.395, to the RCO.

Chapter IV: INDIVIDUAL ISOTOPE USER

A. No person shall begin working with radioactive material until such time as he/she has been approved in writing by the Isotope Committee. The individual shall indicate to the RCO their desire to work with radioactive materials by completing and forwarding copies of Isotope Forms 2, 4, and 6. The ARCS shall assure that each person under his/her direction has read and understands this handbook and the relevant portions of Title 10, Code of Federal Regulations, Parts 19 and 20 (see Section 4 of this manual), and the Nuclear Regulatory Commission license held by Miles Laboratories (see Section 3 of this manual).

B. The Isotope Committee will not approve application from employees under 18 years of age (10 CFR 20.104).

C. Individuals without formal training in the use of isotopes or appropriate experience may be granted temporary approval. They must work under direct supervision of a qualified user for 6 months to obtain an adequate understanding of handling techniques, methods, equipment, and calculations unique to the use of radioactive materials.

D. Occasionally, the medical condition of some employees may require that exposure to hazardous materials be further minimized or eliminated. The isotope committee recommends that such employee be assigned according to the terms described in the Personnel Practices Manual H.11.1. Medical conditions concerning work involvement should be reviewed with the Department of Occupational Health and the Director of Employee Medical Affairs.

E. At the perogative of the Director of Employee Medical Affairs, medical evaluation may be required prior to initiation of radioisotope use or periodically thereafter.

F. Each individual user should strive to keep exposure to radiation as low as reasonably achievable. Laboratory air and water concentrations and surface contamination levels shall be kept to a minimum and, specifically, below those listed in Section 4, Appendix B, Table II of this manual.

G. The user shall wear the prescribed monitoring equipment as indicated in the project's "Protocol for Use of Radioactive Material".

H. The user shall follow all appropriate work procedures as specifically mentioned in this manual and as prescribed in the project's "Protocol for Use of Radioactive Material".

I. Each user shall restrict use of radioisotopes to those areas posted as radioactive material work areas. These areas are restricted to isotope use only to prevent the spread of contamination.

J. Assure that all equipment that comes in contact with radioactive material are labeled and isolated. Once used for radioactive substances, the equipment should not be used for other laboratory work until demonstrated to be free of contamination.

K. Report immediately accidental inhalation, ingestion, or injury to the ARCS, RCO, the Department of Occupational Health, or the designated medical representative.

L. Report immediately to the ARCS or RCO all incidents involving isotopes that might lead to the spread of contamination.

Chapter V: SAFE HANDLING PROCEDURES

A. Protection Against Personal Contamination

1. No smoking, eating, or drinking is permitted in the immediate area where radioactive material is being used.
2. The storage of food and drinks in radioisotope refrigerators, freezers, or cabinets is prohibited.
3. All radioactive solutions are to be pipetted using pipette filling devices.
4. Wear protective clothing whenever contamination is possible.
5. Wear disposable gloves to avoid contact with radioactive materials. Organic solvents will permeate through various gloves. Choose the glove material with respect to the solvent being used.
6. Extreme care must be exercised if working with open cuts below the wrist. Use appropriate glove material to protect contamination of skin.
7. Use protective shields and mechanical devices whenever their aid will assist in reducing exposure. (See Chapter IX of this section for additional information).
8. Wear the prescribed personnel monitoring device.
9. Use appropriate monitoring devices to determine the presence of contamination on hands, clothing, and work area. Each worker is personally responsible to check for contamination before leaving the area.
10. Wash hands and arms thoroughly before handling any object that goes to the mouth, nose, or eyes.

B. Protection Against Laboratory Contamination

1. Areas restricted to radioisotope use are to be kept clean, orderly, and free of unnecessary equipment and supplies.
2. All chemical procedures using radioactive materials are to be carried out on a surface that has an area large enough to accomodate the work to be performed. Congestion can lead to unsafe working conditions.
3. Contamination of the general laboratory air and ventilation system must be avoided. Where the use of isotopes may result in airborne contamination, a suitable hood or glove box must be used with the appropriate filtration system, direct exhaust, and air monitoring devices. (See Chapter IX of this section for additional information).
4. Absorbent paper, with the plastic backing down, should line the interface of work surfaces that could become contaminated.
5. Wherever practical, confine solutions to double containers. In movement about the laboratories, an outer unbreakable container should be used to prevent the possibility of spillage or breakage.
6. The transfer of solutions from one container to another, should be performed within a double container or over an absorbent lined tray or pan to limit and confine spillage and the spread of contamination.

7. Handling equipment that is not contaminated should be placed in a tray or pan located away from the actual work area.
8. A caution label (see Section 4, part 20.203f) shall be applied to all containers actually containing radioactive material; contaminated containers shall be labeled unless attended by an individual who takes precautions necessary to prevent someone else from possible contamination.
9. Contaminated equipment or that suspected of contamination shall be labeled and isolated until decontaminated.
10. Contaminated equipment, supplies, containers, etc., shall not be released from the area for general use until shown to be free of contamination.

C. Protection Against Contamination of Clothing

1. It shall be the responsibility of the designated user to see that appropriate clothing is worn whenever contamination is possible.
2. Such protective clothing shall be monitored at appropriate intervals during usage.
3. Such protective clothing is not to be worn eleswhere, especially in areas where smoking and eating are common practice.

Chapter VI: DECONTAMINATION PROCEDURES

A. Decontamination of Clothing

1. Laboratory clothing should not be released to laundries unless the contamination is below permissible levels. If contaminated with a short-lived isotope, the clothing may be stored until the contamination is reduced to a safe level.
2. Contaminated street clothing should be isolated in plastic bags until they can be laundered. Contact the RCO for assistance in determining appropriate procedures to follow. A separate washing of lightly contaminated clothing can be carried out according to certain procedures:
   a. Begin with several rinsings.
   b. Use standard detergents with longer periods of washing and repeated rinsings for heavy contamination.
   c. Cleaning efficiency of resistant contamination can be accelerated by using complexing agents such as 1% citric acid solution or 10% sodium citrate, or chelating agents such as 1-2% EDTA or 5-10% sodium carbonate in combination with the detergent.
   d. Follow with numerous rinsings and monitor for residual radioactivity. The laundry equipment should be monitored for residual contamination.
3. If neither of the above is practical, discard the clothing as radioactive waste.

B. Decontamination of the Skin

1. The immediate washing of contaminated areas with soap and water is the best general method for decontamination regardless of contaminant, subject to the following:
   a. Tepid water should be used.
   b. The soap should not be abrasive nor highly alkaline.
   c. The skin should be washed for a few minutes at a time, then dried and monitored.
   d. Washing can be repeated if necessary, provided that there is no indication of damage to the skin.
2. If this procedure fails, a commercial skin decontaminating agent can be employed.
3. Special care should be paid to proper decontamination of creases, folds, fingernails, areas between fingers, and the outer edges of the hands.
4. Care should be taken to avoid spreading contamination to uncontaminated parts of the body, and to avoid internal contamination. An open wound should be protected against any further contamination.
5. Avoid the use of organic solvents or alkaline solutions that may increase the probability of radioactive materials penetrating through the pores of the skin.
6. The cleaned area should be dried with fresh non-contaminated towels and monitored.

C. Decontamination of Equipment

1. A decision to decontaminate material must take into account the continuing value of the material compared with effort and cost of decontamination.
2. Equipment should be decontaminated as soon as possible to prevent the contaminant from becoming fixed.
3. Rinse 3 times with an appropriate solvent (aqueous or organic) and dispose of all rinse into the proper radioactive waste container. Rinsing should be performed immediately after use, before the article dries.
4. Place the rinsed equipment in one of several commercially available decontaminating solutions to soak overnight. Pour solution into waste container and mix fresh decontamination solution before scrubbing equipment and washing according to general procedures.
5. Equipment should be monitored and where contamination of more than 3 times above background exists, the equipment should be resoaked or disposed of as radioactive waste.
6. All decontaminating solutions should be monitored for radioactivity before proper disposal.
7. Decontaminated equipment may then be washed according to general cleaning procedures.
8. Alternative cleaning agents for glassware are chromic acid solution, concentrated nitric acid, ammonium citrate, and other chelating agents such as EDTA.
9. Alternatives for metal tools include dilute nitric acid, a 10% solution of sodium citrate, and other chelating agents. Stainless steel could be treated with dilute sulphuric acid or a suitable polish. Cleaning agents should be chosen taking into account the material of which the equipment is made and the likely chemical nature of the contaminant.
10. If the decontamination causes any corrosion of the metal, any future contamination will be more difficult to remove. A new coat of paint may be desirable.
11. Surfaces of paintwork can be cleaned with soap or detergent and water, commercial preparations, or in extreme cases removed with paint remover and repainted.
12. Floor surfaces can be cleaned with detergent and water, commercial preparations, or in extreme cases the wax polish may need to be removed and rewaxed. Floor tile can be removed and replaced if defaced by solvent spills.

Chapter VII: PERSONNEL MONITORING

A. Prior to the start of initial work, all personnel who will work with radioactive material must first complete Isotope Personnel forms 2, 4, and 6.

B. Film badges will be assigned to personnel employed on long-term projects when working with the following: 1 MeV or greater beta emitters, all gamma emitters used in quantities greater than 1.0 millicurie or at the discretion of the RCO, all neutron sources, and x-ray producing equipment. Film badges need not be worn when it has definitely been established by the RCO that exposures will not exceed the limits specified in Section 4, part 10 CFR 20.202. When not in use film badges must be stored in a location away from radiation, excessive heat, or moisture.

C. Pocket dosimeters may be assigned for short term projects subject to all of the above. A record of exposure recorded by each dosimeter will be maintained by the RCO.

D. Records of personnel monitoring shall be maintained by the RCO (see Section 4, part 10 CFR 20.401 a and c) and are available upon request subject to 10 CFR 19.13 (see Section 4).

E. Bioassays

1. Urinalysis may be required whenever tritiated water could arise during the use of the material.
2. Projects involving tritium in amounts greater than 100 millicuries will require daily urinalysis during short-term projects and weekly on long-term projects (Form #4.922).
3. Thyroid scans will be required of personnel involved directly in Iodine-125 tagging operations in excess of 10 millicuries. A pre-operational baseline measurement shall be taken within 2 weeks prior to beginning work and again within 72 hours following subsequent use of Iodine-125. Long term use may vary this procedure. (Form #4.990)
4. Bioassays with other isotopes and at lower amounts may be prescribed at the discretion of the RCO.

F. Limits of exposure of individuals to radiation in restricted areas are defined in 10 CFR 20.101 and 20.103 (see Section 4).

Chapter VIII: RESTRICTED AREAS

A. No radioactive material shall be used or stored in any area until the ARCS has provided the RCO with a line drawing of the area showing its relationship o the rest of the building and this area has been approved by the RCO.

B. Each area in which licensed material is used and/or stored shall be conspicuously posted with the conventional radiation caution colors (magenta on yellow background) and bear the conventional radiation symbol and the words: "Caution Radioactive Materials". Only those personnel immediately concerned with the isotope work shall be permitted to use the restricted area.

C. An area possessing higher levels of radiation exposure, such that an individual could receive a dose in excess of 5 millirem/hour or in any 5 days a dose in excess of 100 millirem would be posted as: "Caution Radiation Area".

D. 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 does not exceed 5 millirem/hour.

E. Any room or enclosure in which airborne radioactive material meets the criteria stated in 10 CFR 20.203 d (see Section 4) shall be posted: "Caution Airborne Radioactivity Area".

F. Caution signs are not required to be posted at areas containing radioactive materials for periods less than 8 hours provided such materials are constantly attended by an individual who will prevent unnecessary exposure during such periods.

G. Caution signs are not required to be posted at areas containing radioactive materials prepared for transport and packaged and labeled in accordance with regulations of the Department of Transportation.

H. Any area deleted from restricted isotope use must be reported to the RCO. The area must be monitored and recorded as being free of contamination, with all caution signs removed before it can be released for common use.

Chapter IX: SPECIAL EQUIPMENT

A. Whenever there is a possibility that particulate, volatile, or gaseous radioactive materials will be released in the air, the procedure must be done in a properly enclosed and vented fume hood.

1. The air velocity flowing into the hood should be between 100-150 linear feet/minute, as certified by Miles Power Maintenance Department, and exhausted directly outdoors.
2. All necessary filtration devices, as required by the nature of isotope in use, must be maintained and checked to insure their integrity.
3. All releases shall not exceed the maximum permissible guidelines in air for the isotope in use without the prior consent of the RCO. See Appendix B, Table II of 10 CFR 20 for appropriate values.

B. Shielding materials are to be used appropriate to the types and levels of radiation in all laboratories.

1. Gamma emitters are to be shielded with high density material such as lead. Thickness is dependent on activity level and degree of protection desired.
2. Hard beta emitters are to have a first layer of shielding of low density material to prevent bremsstrahlung radiation. Material such as lucite, plexiglass, or PVC plumbing are good shields. A plexiglass glovebox of ¼ inch thickness may be desirable for long-term projects. If activity in storage is large and bremsstrahlung is produced through the first layer of shielding, a second layer of lead should be used absorb the x-rays.
3. All stored materials must be shielded such that the dose rate 12 inches from the surface of the container will not exceed 5 millirem/hour.

C. Equipment to maintain exposure as low as reasonably achievable shall be employed at all times. Items needed may include different types of shielding, remote handling devices, pipette filling devices, gloves, lab coats, double containers, trays, absorbent bench protectors, and other specific items.

D. Survey instruments must be available that are appropriate to the type and level of ionizing radiation used.

1. Soft beta emitters and low energy gamma (I-125) are best monitored by laboratory contamination survey techniques (surface wipe tests).
2. All gamma and hard beta emitters can be monitored with portable or area survey meters. These are to be purchased by the individual laboratory for long-term projects. Instruments may be borrowed from the Radiation Control Office for short-term projects. The Radiation Control Office will aid in the selection of appropriate instruments for purchase and in methods of operation.
3. Survey instruments must be calibrated annually by the Radiation Control Office.

Chapter X: LABORATORY MONITORING

A. All isotope work areas or restricted areas, as discussed in Chapter VIII previously, are required to be surveyed.

1. It shall be the responsibility of the ARCS to establish appropriate procedures for such surveys and to insure that the surveys are conducted on a monthly basis, per NRC license conditions.
2. A wipe test appropriate to the isotopes used shall be made of all work areas. Two examples are included in the isotope forms section 5 of this manual, i.e. isotope forms #18 and #20.
   a. Select filter paper of a size appropriate to the vial or counting tube used.
   b. Soak in solvent that will remove contaminant (50% ethanol or 0.9% sodium chloride).
   c. Wipe paper over a sampling area of 100 cm^2.
   d. Count sample three times, for a minimum of 5 minutes each, to obtain a statistical accuracy.
   e. Record on survey report form.
   f. An observed count rate more than three times the background count rate will require decontamination of work area: scrub with soap and water, commercial decontamination preparations, 50% ethanol, or solvent appropriate to contaminant; take precautions to avoid spreading the contamination to adjacent areas; then rinse area with water and recount.
   g. Record all information, retain a copy, and send original to the Radiation Control Office.

B. Areas possessing high level gamma emitters, high level beta emitters, finished products, sealed sources, and storage areas of same will require routine monitoring of radiation levels with a portable survey meter. An example of G-M survey reading is included in the isotope forms section 5 of this manual, i.e. isotope form #19.

1. Areas with radiation levels below 5 millirem/hour are to be posted "Caution Radioactive Materials".
2. Areas where radiation levels may expose individuals to 5 millirem in any one hour; or in any five consecutive days, a dose in excess of 100 millirem, shall be posted "Caution Radiation Area".

C. Formal records of the results of all surveys shall be maintained by, and copies of the survey records must be promptly forwarded to, the RCO. Such records must be retained until the NRC authorizes disposition (see Section 4, part 20.401 c).

Chapter XI: PURCHASE AND RECEIPT OF RADIOACTIVE MATERIAL

A. Reference is made to Corporate Procedure No. 6120089 entitled "Radioactive Substances--Ordering, Receiving, and Delivering Process -Elkhart Complex".

B. All vendors of radioactive material are required to possess and read a copy of the purchaser's NRC license before any transfer can be made (10 CFR 30.41). We have furnished most major vendors a copy of our NRC license.

C. All radioactive requests for incoming transfers and purchase must be approved by the RCO. The following items are needed to process an order:

1. Verify that project has an approved protocol number or submit a "Protocol for the Use of Radioactive Materials", isotope form #7, Miles form P.363.
2. Complete "Application for Radioisotope Procurement", isotope form #1, Miles form #4.090.
3. Complete a Miles Purchase Requisition and obtain authorized signature.
4. Obtain Division cost accountant signature.
5. Forward to Radiation Control Office.

D. All radioactive material packages are to be designated for delivery to the Radiation Control Office.

1. Packages are logged in as received.
2. External surfaces are inspected for damage.
3. Certain packages are required, under 10 CFR 20.205 b, to be wipe tested for leakage within three hours of receipt in our facility.
4. Once they are monitored they are delivered immediately to the requisitioner.

E. Each laboratory shall maintain procedures for safely opening all packages in which licensed material is received, and shall assure that these procedures are followed (see Section 4, part 20.205 d).

1. Dependent upon quantity, form, and type of isotope, the following general procedure should be followed:
   a. Since our receiving department is not permitted to open radioactive material packages, it is important to open all packages immediately to verify contents and possible damage.
   b. Place package in vented hood.
   c. Open outer package and remove packing slip. Open inner package and verify that the contents agree in name and quantity with the packing slip.
   d. Check for possible breakage of seals or containers, loss of liquid or change in color of absorbing material.
   e. Wipe test isotope container for possible surface contamination.

f. Compare or record type of activity, quantity present, and location of storage on isotope inventory form #4.196. This form will be provided by the RCO after processing the purchase requisition.
g. Deliver processed package to requisitioner. If delivery is delayed, notify requisitioner of its arrival and clearance.
h. If material has been packaged in dry ice, refrigerate or deliver immediately to ultimate user.
i. If contamination, leakage, or shortages are observed, notify the RCO and the vendor's Customer Service Department immediately by collect telephone call.

2. Any specific instructions included with the package must be followed.

F. Prior to disposal, reuse, or transfer of an empty radioactive material container to unrestricted areas, remove or deface the radioactive material label or otherwise clearly indicate that the container no longer contains radioactive material (see Section 4, part 20.203 f.4).

Chapter XII: ISOTOPE INVENTORY

A. The Radiation Control Office will issue an inventory number to each container of radioactive material.

B. A continuous record of each item is to be maintained from receipt to its final disposition. This can conveniently be done by the consistent use of form #4.196, which is mailed to the requisitioner by the Radiation Control Office.

C. It shall be the responsibility of the ARCS to maintain current inventories of isotopes in his/her possession. Inventory adjustments include uses of material, radioactive decay, transfers, and final waste disposition.

D. When original material is used to synthesize other usable material, this should be shown as deleted from the original inventory. A new inventory record (Form 4.196) should be initiated for the new material, including the original inventory lot number from which it was synthesized.

E. Except during periods of use, all isotopes shall be stored in specified central locations within using areas; employing all appropriate shielding and under the control of the ARCS. Note that storage of radioactive material in unrestricted areas is subject to conditions stated in Section 4, parts 20.105 b and 20.207.

F. All isotopes released to personnel shall be protected to prevent spillage of material or unnecessary exposure to all personnel. Any theft or loss of large quantities of radioactive materials are to be reported immediately.

G. Notify the RCO of any inventory transfers between using laboratories within the company to facilitate inventory control of the item.

1. Delete from original isotope inventory form #4.196.
2. Prepare a new form #4.196 including all available information for the receiving laboratory and attach to the material being transferred.

H. The total complex inventory will be adjusted quarterly on the basis of a physical inventory of research and development isotopes performed by the ARCS and reported to the RCO using form #4.398. A similar inventory is conducted quarterly of finished goods distributed by Miles. This total inventory is essential to assure full compliance with the license possession limits.

Chapter XIII: SHIPPING RADIOACTIVE MATERIALS

A. The shipping of radioactive material as either a transfer or for sale must receive prior approval of the Radiation Control Office.

1. Routine shipments must be approved for methods and packaging employed.
2. Non-routine shipments - the shipper will receive assistance from the Radiation Control Office.

B. The recipient of any radioactive material to be shipped from Miles must provide evidence of an NRC (or Agreement State) license by furnishing a copy of his license to the Miles Radiation Control Office before shipment can be made. Non-compliance with this requirement is a violation of the Atomic Energy Act and is subject to criminal prosecution. If a valid license is not already in our possession, request a copy from the recipient in order to fulfill this requirement and speed processing of the shipment.

C. Radioactive material leaving the company must be packaged, labeled, and shipped in accordance with the applicable regulations governing the mode of transportation, as regulated by the Materials Transportation Bureau of the Department of Transportation. The Radiation Control Office works in cooperation with the Miles Traffic Department to assure compliance with these ever changing regulations.

D. Radioactive material leaving the company must be deleted from the inventory of the shipper (research laboratories use inventory form #4.196)

Chapter XIV: RADIOACTIVE WASTE DISPOSAL

The accumulation of radioactive waste must be collected in containers separate from conventional waste in order to maintain inventory control and to insure proper disposition of the material. Due to the increasing difficulties associated with waste disposal, a number of specific points need to be emphasized:

1. Care must be exercised to separate radioactive waste from non-radioactive waste. Non-radioactive waste is an expensive burden.

2. Work planning should include thought in minimizing the generation of waste.

3. The segregation of material according to burnable and non-burnable is important in the final disposition. Only the generator can conveniently separate such material.

4. Follow any additional procedures provided by the RCO to facilitate waste handling operations.

Waste accumulated by individual users must be prepared for transfer to the central collection center in the proper containers, accompanied by a completed form #4.395 (Kankakee facility uses form #7.595) and in accordance with the following:

A. Solid Waste - special plastic-lined waste containers are available from the Radiation Control Office for disposal of dry contaminated waste. These are to be located in all laboratories using radioisotopes.

1. All such containers must be conspicuously labeled with radioactive material caution signs.
2. A container for burnables shall be maintained separate from non-burnables and labeled appropriately.
3. Separate material that will incinerate at temperatures up to 1400°F (760°C) from non-burnable material.
4. Burnable material should be relatively low in activity in order to meet the MPC emission guidelines.
5. The contaminated waste shall be sealed in the plastic bag for disposal by the RCO.

B. Liquid Waste - special containers (non-breakable plastic is preferred) for non-flammable and the appropriate safety can for flammable solvents shall be available in each laboratory use area. All primary liquid waste shall be retained. In general, only low activity water soluble waste, such as that associated with secondary wash water should be allowed to go into the sewer. In no case should amounts exceed 0.01 millicuries without first consulting the RCO.

1. All such containers must be conspicuously labeled with radioactive material caution signs.
2. Containers of volatile liquid waste shall contain appropriate additives to prevent volitilization of the radioactive material.
3. All strong acid or base liquid waste must be neutralized before disposal.
4. Each bottle shall contain no more than one isotope and no immiscible liquids shall be contained together.
5. Incompatible chemicals shall be called to the attention of the RCO.

C. Liquid Scintillation Vials

1. Scintillation vials containing scintillator should be replaced in their original trays for transfer to the collection center.

D. Animal Carcasses and Animal Wastes

1. All radioactive animal carcasses and tissues must be placed in plastic bags, conspicuously labeled with radioactive material caution tape, isotope and activity, then frozen.
2. Animal urine may be handled as liquid waste.
3. Animal feces will need to be dried, absorbed, or solidified for disposal as solid waste.
4. Animal tissue should be placed in a container. All liquid must be absorbed with vermiculite or similar absorbent for disposal as solid waste.

E. Airborne Radioactive Emission

1. Airborne emissions are subject to concentration limits as specified by the NRC in Appendix B of 10 CFR 20 for each isotope. Consult with the RCO for monitoring techniques.

F. Waste Pick-up

1. Request for removal of radioactive waste may be made by telephone to the Radiation Control Office.
2. At the time of pick-up, the investigator must be able to estimate, with a fair degree of accuracy, the amount of radioactive waste in each container.

G. Records

1. Records of disposal by isotope, activity, and form are required at time of transfer to the collection center.
2. In addition to all containers bearing the caution tape, each container should be identified with the appropriate disposal records form #4.395 (Kankakee facility uses form #7.595).

3. The following information should be supplied on the form:
   a. date
   b. isotope
   c. user's name and department
   d. type of waste (liquid, combustible, or non-combustible solid)
   e. description of contents (nature of material in exact terms)
   f. chemical contents (principal solvent, reagent, or most toxic form)
   g. activity (show determination)

Chapter XV: SEALED SOURCES AND REFERENCE STANDARDS

A. A sealed source is one in which radioactive material is permanently encapsulated (in stainless steel, plastic, glass, or other material) to prevent leakage and in which the intent is to utilize the radiation emitted rather than the material itself. Reference standards and calibration sources are included in this category.

B. The ARCS shall advise the RCO of all sealed sources in his/her possession, and the requisition of such items, using form #4.400.

C. The RCO will determine if periodic leak-testing of the source is required and, if so, will establish an appropriate procedure.

D. It will be the responsibility of the ARCS and the RCO to insure that these leak-testing requirements are met and that records of the tests be kept on form #4.402, if applicable.

E. In general, isotopes with a half-life greater than 30 days and containing more than 100 microcuries of beta and/or gamma emitting radiation will require a leak-test every six months.

F. In the event a leak-test reveals the presence of 0.005 microcuries or more removable contamination, the source will be removed from service, decontaminated, repaired, or disposed as solid radioactive waste.

G. The inventory of sealed sources, reference standards, or calibration sources shall be maintained by the ARCS and summarized each quarter on form #4.398.

Chapter XVI: ACCIDENT AND EMERGENCY PROCEDURES

A. Emergencies will generally be in the nature of spills involving radioactive contamination. The following steps should be followed:

1. Advise other personnel in the area of the accident. Prevent others from entering the area and allow only the minimum number of persons to deal with the spill. If necessary, vacate the room at once.
2. In case of major spills notify the RCO and call the security emergency number for assistance.
3. Then prevent the spread of contamination. Confine the spill by dropping absorbent paper around liquid spills or by dampening dry spills (taking care not to use incompatible materials).
4. Do not permit an untrained person to clean up the radioactive material. Decontamination is to be performed by laboratory personnel, not by janitorial service.
5. Be available to the RCO to answer any questions concerning the spill (isotope, chemical solution, amount spilled, etc.).
6. The RCO will investigate with the ARCS the cause of the accident and measures required to prevent reoccurrence.

B. General Principles

Successful decontamination calls for planned action. The person responsible for the spill in a contamination accident will usually take the first steps in bringing the situation under control. The first consideration will be personnel safety; persons not involved will leave the area and prevent untrained personnel from entering. The second item of consideration is to solicit trained help and confine contamination to the immediate area. Those persons responsible for the spill shall decontaminate the area of concern under the supervision and assistance of the RCO. Subsequent considerations should involve the following procedure:

1. The area shall be decontaminated until all removable activity is eliminated. This will be considered complete when contamination levels are less than 3 times above background.
2. Fixed contamination must be reduced to the practical minimum. This may require removal and replacement of the surface or resurfacing of the intact item.
3. Make full use of monitoring methods and available assistance. One person should remain uncontaminated to operate instruments and to do other monitoring. Each step of the decontamination should be monitored.
4. Any person involved in the spill and decontamination shall be monitored for contamination of hands and clothing immediately after the clean-up is finished.
5. Permit no person to work in the area until approval of the RCO is obtained.

C. All accidental inhalation, ingestion, or injury involving radioactive materials must be reported to the RCO and the individual must cooperate in any and all attempts to evaluate his exposure. Wash all minor wounds immediately. All work related injuries are to be treated by the Dept. of Occupational Health, or contact physicians.

D. In case of fires involving radioactive material, attempt to put out the fire if a radiation hazard is not immediately present. In most cases, radiation will not be a hazard during the first few minutes when a fire extinguisher may be successful. Containing the fire immediately will prevent additional spread of both hazards.

If immediate attempts are unsuccessful, call the security emergency 8400 number. Subsequent activities to be governed by the restrictions of the Fire Department and the RCO.

E. Depending upon the severity of an accident, it may be necessary to notify the NRC.

GLOSSARY

The definitions included in this Glossary are from several sources: *Electronics and Nucleonics Dictionary*, 3rd Edition, published by McGraw-Hill Book Co. and the *Radiological Health Handbook*, Revised Edition January 1970, by the U.S. Dept. of Health, Education, and Welfare.

Absorbed Dose (rad). The absorbed dose of any ionizing radiation is the energy imparted to matter by ionizing particles per unit mass of irradiated material at the place of interest.

Activity. The number of nuclear transformations occurring in a given quantity of material per unit time. (See Curie.)

Air Dose (free air dose). A dose of radiation measured in air at the point of interest in the absence of patient (or phantom) or other object, thus excluding secondary radiation apart from that arising from the air or associated with the source.

Alpha Decay. The radioactive transformation that occurs when an alpha particle is emitted by a nuclide. The decay product is a new nuclide having a mass number four units smaller and an atomic number two units smaller than the original nuclide.

Alpha Emitter. A radionuclide that undergoes transformation by alpha-particle emission.

Alpha Particle (α). A positively charged particle having two protons and two neutrons. It is emitted from certain radioactive elements or isotopes, has high ionizing power but little penetrating ability, and can damage living tissue. An alpha particle is identical in all measured properties with the nucleus of a helium atom.

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

Atomic Number (Z). The number of elementary positive charges in the nucleus of an atom. It is a different number for each element, and ranges from 1 for hydrogen to 103 for the heaviest known element. For a neutral atom, the atomic number is also the number of electrons outside the nucleus of the atom. In the symbol of a nuclide, the atomic number is given as a subscript preceding the element symbol; thus, in $^{59}_{26}Fe_{33}$, the atomic number for iron is 26, the neutron number is 33, and the mass number is 59.

Attenuation. The process by which a beam of radiation is reduced in intensity when passing through some material. It is the combination of absorption and scattering processes and leads to a decrease in flux density of the beam when projected through matter.

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

Background Count. A count caused by ionizing radiation coming from sources other than that being measured.

Beta Decay. Radioactive transformation of a nuclide in which the atomic number increases or decreases by 1 and the mass number remains unchanged. The atomic number increases when a negative beta particle (negatron) is emitted and decreases when a positive beta particle (positron) is emitted or an electron is captured.

Beta Emitter. A radionuclide that disintegrates by beta particle emission.

Beta Particle (β). A negative electron (negatron) or a positive electron (positron) emitted from a nucleus during beta decay.

Body Burden, Maximum Permissible (q). The amount of radioactive material in the critical organ so it is receiving 0.3 rem/week.

Bremsstrahlung. The production of electromagnetic radiation by the deceleration of a charged particle, usually an electron, while passing through matter. Examples are the continuous spectrum from an X-ray tube, and the electromagnetic radiation often noted from pure β emitters such as ^{32}P and ^{90}Sr.

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

Coincidence. The occurrence of counts in two or more detectors simultaneously or within an assignable time interval. A *true coincidence* is one that is due to the incidence of a single particle or of several genetically related particles.

Contamination, Radioactive. Deposition of radioactive material in any place where it is not desired, particularly where its presence may be harmful. The harm may be in vitiating an experiment or a procedure, or in actually being a source of danger to personnel.

Controlled Area. A defined area in which the occupational exposure of personnel (to radiation) is under the supervision of the Radiation Protection Supervisor.

Cosmic Rays. Penetrating ionizing radiation, both particulate and electromagnetic, originating in outer space. Secondary cosmic rays, formed by interactions in the earth's atmosphere, add to the general background radiation.

Count (as in counts/minute). The external indication of a device designed to enumerate ionizing events. It may refer to a single detected event or to the total number registered in a given period of time. The term often is erroneously used to designate a disintegration, ionizing event, or voltage pulse.

Counter, Geiger-Mueller. Highly sensitive, gas-filled radiation-measuring device. It operates at voltages sufficiently high to produce avalanche ionization.

Counter, Proportional. Gas-filled radiation detection device; the pulse produced is proportional to the number of ions formed in the gas by the primary ionizing particle.

Counter, Scintillation. The combination of a phosphor (converts ionizing particle energy to light pulse), a photomultiplier tube (converts light pulse to many electric pulses), and associated circuitry for counting the electric pulses.

Counting, Coincidence. A technique in which particular types of events are distinguished from background events by coincidence circuits which register coincidences caused by the type of events under consideration.

Counting Ratemeter. An instrument which gives a continuous indication of the average rate of ionizing events.

Counting Error. Specifies the reliability of a measurement.

Critical Organ. The body organ receiving the radionuclide that results in the greatest over-all damage to the body. Usually, but not necessarily, it is the organ receiving the greatest concentration or the organ receiving the greatest damage.

Curie. The special unit of activity. One curie equals 3.700×10^{10} nuclear transformations per second, or 2.22×10^{12} disintegrations per minute. (Abbreviated Ci.) Several fractions of the curie are in common usage. See 10 CFR 20.5.

Millicurie. One-thousandth of a curie (3.7×10^{7} disintegrations per second), or 2.22×10^{9} disintegrations per minute.(abbreviated mCi)

Microcurie. One-millionth of a curie (3.7×10^{4} disintegrations per sec.), or 2.22×10^{6} disintegrations per minute. Abbreviated μCi.

Picocurie. One-millionth of a microcurie (3.7×10^{-2} disintegrations per second or 2.22 disintegrations per minute). Abbreviated pCi.

Decay Constant (λ). The fraction of the number of radioisotope atoms which decay in unit time. Decay constant is $0.693/T_p$ where T_p is the half-life.

Decay Product. A nuclide resulting from the radioactive disintegration of a radionuclide or series of radionuclides. A decay product may be either stable or radioactive.

Decay, Radioactive. The spontaneous transformation of a nuclide into one or more different nuclides. The process involves (a) the emission from the nucleus of alpha particles, electrons, positrons, and gamma rays, (b) the nuclear capture or ejection of orbital electrons, or (c) fission. The rate of radioactive decay is expressed in terms of the half-life of the nuclide. Also called decay, nuclear spontaneous reaction, radioactive disintegration, and radioactive transformation.

Disintegration, Nuclear. Process of spontaneous breakdown of a nucleus of an atom resulting in the emission of a particle and/or a photon. The rate of disintegration of a quantity of any radioactive nuclide is a function of the number of atoms present and a disintegration or decay constant characteristic of the nuclide concerned.

Disintegration Rate The absolute rate of decay of a radioactive substance, usually expressed in terms of disintegrations per unit of time.

Dose, Cumulative (Radiation). The total dose resulting from repeated exposures to radiation.

Dose Equivalent (DE). A quantity used in radiation protection. It expresses all radiations on a common scale for calculating the effective absorbed dose. It is defined as the product of the absorbed dose in rads and certain modifying factors. (The unit of dose equivalent is the rem).

Dose, Permissible. The dose of radiation which may be received by an individual within a specified period with expectation of no significantly harmful result.

Dosimeter. Instrument to detect and measure accumulated radiation exposure. In common usage, a pencil-size ionization chamber with a self-reading electrometer, used for personnel monitoring.

Efficiency. A factor used to convert the counting rate of a detector to the disintegration rate of the radioactive material counted. Since usage and factors involved vary considerably with different detectors, it is well to ascertain which factors (window transmission, sensitive volume, energy dependence, etc.) are included in a stated efficiency.

Electron Capture. A radioactive transformation of a nuclide in which a bound electron merges with its nucleus. This decreases the atomic number by 1 but leaves the mass number unchanged in the new nuclide. A proton is transformed to a neutron within the nucleus, a bound electron is taken up, and a neutrino emerges. Examples are K-electron, L-electron, and M-electron capture.

Electron Volt. A unit of energy equivalent to the energy gained by an electron in passing through a potential difference of one volt. Larger multiple units of the electron volt are frequently used: *keV* for thousand or *kilo electron volts; MeV* for million or *mega electron volts.* (Abbreviated eV, $1\ eV = 1.6 \times 10^{-12}$ erg.).

Error, Statistical. Errors in counting due to the random time-distributions of disintegrations.

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

Extremities. The hands and forearms, and with restrictions, the head, feet and ankles. Permissible exposures in these regions are generally greater as they contain less blood-forming material and have smaller volume for energy absorption than other body parts.

Film Badge. A pack of photographic film which measures radiation exposure for personnel monitoring. The badge may contain two or three films of differing sensitivity and filters to shield parts of the film from certain types of radiation.

Gamma Emitter. An atom whose radioactive decay process involves the emission of gamma rays.

Gamma Ray (γ). A quantum of electromagnetic radiation emitted by a nucleus as the result of a quantum transition between two energy levels of the nucleus. Gamma rays have energies usually between 10 kilo-electron-volts and 10 million electron-volts, with shorter wavelengths than x-rays. They are more penetrating than alpha and beta particles and are not affected by magnetic fields.

Generators, Nuclide. A device in which a daughter radionuclide is eluted from an ion exchange column containing a parent radionuclide long-lived compared to the daughter.

Genetic Effect of Radiation. Inheritable change, chiefly mutations, produced by the absorption of ionizing radiations. On the basis of present knowledge these effects are purely additive; there is no recovery.

Half-Life, Biological. The time required for the body to eliminate one-half of an administered dosage of any substance by regular processes of elimination. Approximately the same for both stable and radioactive isotopes of a particular element.

Half-Life, Effective. Time required for a radioactive element in an animal body to be diminished 50 percent as a result of the combined action of radioactive decay and biological elimination.

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

Half-Life, Radioactive. Time required for a radioactive substance to lose 50 percent of its activity by decay. Each radionuclide has a unique half-life.

Half Value Layer (Half Thickness) (HVL). The thickness of a specified substance which, when introduced into the path of a given beam of radiation, reduces the exposure rate by one-half.

Health Physics. A science and profession devoted to the protection of man and his environment from unnecessary radiation exposure.

Health, Radiological. The art and science of protecting human beings from injury by radiation, and promoting better health through beneficial applications of radiation.

Internal Conversion. A nuclear deexcitation process in which energy is transmitted directly from an excited nucleus to an orbital electron, causing ejection of that electron from the atom. The ejected electron is called a conversion electron. Subsequent filling of the vacancy in the shell of the atom is accompanied by emission of photons, producing characteristic x-rays.

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

Ionization. The process by which a neutral atom or molecule acquires a positive or negative charge.

Isotopes. Nuclides having the same number of protons in their nuclei, and hence the same atomic number, but differing in the number of neutrons, and therefore in the mass number. Almost identical chemical properties exist between isotopes of a particular element. The term should not be used as a synonym for nuclide.

K-electron Capture. The radioactive decay process in which an orbital electron from the K shell of an atom is captured by the nucleus of that atom. It results in the production of x-rays characteristic of the daughter atom. Other examples of such electron capture are L-electron capture and M-electron capture.

Kilo Electron Volt (keV). See Electron Volt.

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

Mass Number (A). The number of nucleons (neutrons and protons) in the nucleus of an atom.

Maximum Permissible Accumulated Dose. The dose of ionizing radiation that a person may receive in his lifetime without appreciable bodily injury. See 10 CFR 20.102.

Maximum Permissible Concentration. The highest currently acceptable concentration of radioactive substances, usually expressed in microcuries per cubic centimeter, in air, water, or food, to which an individual may be exposed throughout a stated period of time without expectation of injury. See 10 CFR 20.103.

Maximum Permissible Exposure. The total amount of radiation exposure to which a normal person may be subjected day by day without any harmful effects becoming evident during his lifetime. See 10 CFR 20.101.

Mega Electron Volt (MeV). See Electron Volt.

Monitoring. Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in an occupied region.

Area Monitoring. Routine monitoring of the radiation level or contamination of a particular area, building, room, or equipment. Some laboratories or operations distinguish between routine monitoring and survey activities.

Personnel Monitoring. Monitoring any part of an individual, his breath, or excretions, or any part of his clothing.

Neutron (n). An elementary nuclear particle having zero charge and mass number 1, making its mass approximately the same as that of a proton. Ionization is produced by the products of neutron collisions.

Nuclide. A species of atom having a specific mass number (A), atomic number (Z), and energy state.

Photon. A quantity of electromagnetic energy (E) whose value in joules is the product of its frequency (υ) in hertz and Planck constant (h). The equation is: $E = h\upsilon$.

Quality Factor (QF). The linear-energy-transfer-dependent factor by which absorbed doses are multiplied to obtain (for radiation protection purposes) a quantity that expresses - on a common scale for all ionizing radiations - the effectiveness of the absorbed dose.

Rad (rad). The unit of absorbed dose. It is 100 ergs/g of any material.

Radiation:

Annihilation Radiation. Photons produced when an electron and a positron unite and cease to exist. The annihilation of a positron-electron pair results in the production of two photons, each of 0.51 MeV energy.

Characteristic (discrete) Radiation. The essentially monochromatic radiation emitted by an atom when an orbital electron is removed or following excitation of the atom. Each element may emit a number of characteristic radiations, each of a constant wavelength and different from the characteristic radiations of all other elements.

External Radiation. Radiation from a source outside the body - the radiation must penetrate the skin.

Internal Radiation. Radiation from a source within the body (as a result of deposition of radionuclides in body tissues).

Ionizing Radiation. Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.

Scattered Radiation. Radiation which during its passage through a substance, has been deviated in direction. It may also have been modified by a decrease in energy.

Secondary Radiation. Radiation, electromagnetic or particulate, originating as the result of radiation attenuation in matter. Examples: Secondary cosmic rays, photoelectrons, recoil protons from neutron-proton collisions, and bremsstrahlung from radioactive isotopes.

Radioactive Standard. A sample of radioactive material, usually with a long half-life, in which the number and type of radioactive atoms at a definite reference time is known. Used for calibrating radiation-measuring equipment. Also called reference source.

Radioactivity. The property of certain nuclides of spontaneously emitting particles or gamma radiation or of emitting x radiation following orbital electron capture or of undergoing spontaneous fission.

Artificial Radioactivity. Manmade radioactivity produced by particle bombardment or electromagnetic irradiation, as opposed to natural radioactivity.

Natural Radioactivity. The property of radioactivity exhibited by more than fifty naturally occurring radionuclides.

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

Radiobiology. That branch of biology which deals with the effects of radiation on biological systems.

Radiochemistry. The aspects of chemistry connected with radionuclides and their properties, with the behavior of minute quantities of radioactive materials by means of their radioactivity, and the use of radionuclides in the study of chemical problems.

Radiography. The making of shadow images on photographic emulsion by the action of ionizing radiation. The image is the result of the differential attenuation of the radiation in its passage through the object being radiographed.

Radiology. That branch of medicine which deals with the diagnostic and therapeutic applications of radiant energy including x-rays and radionuclides.

Radiopharmaceutical. A pharmaceutical compound which has been tagged with a radionuclide.

Range (of α or β particles). The distance a particle will penetrate a given material before all its ionizing power is spent.

Relative Biological Effectiveness (RBE). The RBE is a factor used to compare the biological effectiveness of absorbed radiation doses (i.e., rads) due to different types of ionizing radiation, more specifically, it is the experimentally determined ratio of an absorbed dose of a radiation in question to the absorbed dose of a reference radiation required to produce an identical biological effect in a particular experimental organism or tissue. *NOTE: This term should not be used in radiation protection.* (See Quality Factor).

Rem. A special unit of dose equivalent. The dose equivalent in rems is numerically equal to the absorbed dose in rads multiplied by the quality factor, the distribution factor, and any other necessary modifying factors. Abbreviation for roentgen equivalent man. See 10 CFR 20.4

Roentgen (r). An exposure dose of X or γ radiation such that the associated corpuscular emission per 0.001293 g of air produces in air ions carrying 1 esu of quantity of electricity of either sign.

Sealed Source. A radioactive source sealed in an impervious container which has sufficient mechanical strength to prevent contact with and dispersion of the radioactive material under the conditions of use and wear for which it was designed.

Self-Absorption. Absorption of radiation (emitted by radioactive atoms) by the material in which the atoms are located; in particular, the absorption of radiation within a sample being assayed.

Shield. A body of material used to prevent or reduce the passage of particles or radiation. A shield may be designated according to what it is intended to absorb (as a gamma-ray shield or neutron shield), or according to the kind of protection it is intended to give (as a background, biological, or thermal shield). It may be required for the safety of personnel or to reduce radiation enough to allow use of counting instruments for research or for locating contamination or airborne radioactivity.

Specific Activity. Total activity of a given nuclide per gram of a compound, element, or radioactive nuclide.

Tracer, Isotopic. The isotope or non-natural mixture of isotopes of an element which may be incorporated into a sample to permit observation of the course of that element, alone or in combination, through a chemical, biological, or physical process. The observations may be made by measurement of radioactivity or of isotopic abundance.

Transition, Isomeric. The process by which a nuclide decays to an isomeric nuclide (i.e., one of the same mass number and atomic number) of lower quantum energy. Isomeric transitions, often abbreviated I.T., proceed by gamma ray and/or internal conversion electron emission.

Transmutation. Any process in which a nuclide is transformed into a different nuclide, or more specifically, when transformed into a different element by a nuclear reaction.

Tritium. The hydrogen isotope with one proton and two neutrons in the nucleus. Symbol: $^{3}_{1}H$ or T).

X Rays. Penetrating electromagnetic radiations whose wave lengths are shorter than those of visible light. They are usually produced by bombarding a metallic target with fast electrons in a high vacuum. In nuclear reactions, it is customary to refer to photons originating in the nucleus as gamma rays, and those originating in the extranuclear part of the atom as x-rays.

Form NRC-374

U. S. NUCLEAR REGULATORY COMMISSION
MATERIALS LICENSE

Amendment No. 33

This Copy Is For Your Files

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974 (Public Law 93-438), and Title 10, Code of Federal Regulations, Chapter 1, Parts 30, 31, 32, 33, 34, 35, 36, 40 and 70, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, possess, and transfer byproduct, source, and special nuclear material designated below; to use such material for the purpose(s) and at the place(s) designated below; to deliver or transfer such material to persons authorized to receive it in accordance with the regulations of the applicable Part(s); and to import such byproduct and source material. This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, as amended, and is subject to all applicable rules, regulations and orders of the Nuclear Regulatory Commission now or hereafter in effect and to any conditions specified below.

Licensee	
1. Miles Laboratories, Inc.	In accordance with application dated March 20, 1978,
	3. License number 13-02249-01 is amended in its entirety to read as follows:
2. 1127 Myrtle Street Elkhart, Indiana 46514	4. Expiration date December 31, 1983
	5. Docket or Reference No.

6. Byproduct, source, and/or special nuclear material	7. Chemical and/or physical form	8. Maximum amount that licensee may possess at any one time under this license
A. Any byproduct material with Atomic Numbers between 1 and 83, inclusive	A. Any	A. Not to exceed 100 millicuries per radionuclide except: Hydrogen 3 - 3 curies total Carbon 14 - 250 millicuries total Iodine 125 - 800 millicuries total

9. Authorized use

A. For possession, storage and use in research and development as defined in Section 30.4(q), 10 CFR Part 30, and processing for commercial distribution.

CONDITIONS

10. Licensed material shall be used only at the locations specified in Part 1, Item 1(b) of the attachment to the licensee's application dated March 20, 1978.

11. The licensee shall comply with the provisions of Title 10, Chapter 1, Code of Federal Regulations, Part 19, "Notices, Instructions and Reports to Workers; Inspections" and Part 20, "Standards for Protection Against Radiation."

(continued)

12. Licensed material shall be used by, or under the supervision of, individuals designated by the licensee's Isotope Committee, Max Ben, Chairman.

13. A. (1) Each sealed source acquired from another person and containing licensed material, other than Hydrogen 3, with a half-life greater than thirty days and in any form other than gas shall be tested for contamination and/or leakage prior to use. In the absence of a certificate from a transferor indicating that a test has been made within six months prior to the transfer, a sealed source received from another person shall not be put into use until tested.

(2) Notwithstanding the periodic leak test required by this condition, any licensed sealed source is exempt from such leak tests when the source contains 100 microcuries or less of beta and/or gamma emitting material or 10 microcuries or less of alpha emitting material.

(3) Except for alpha sources, 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 months prior to the date of use of transfer.

B. Each sealed source fabricated by the licensee shall be inspected and tested for construction defects, leakage, and contamination prior to use or transfer as a sealed source. If the inspection or test reveals any construction defects or 0.005 microcurie or greater of contamination, the source shall not be used or transferred as a sealed source until it has been repaired, decontaminated and retested.

C. Each sealed source containing licensed material, other than Hydrogen 3, with a half-life greater than thirty days and in any form other than gas shall be tested for leakage and/or contamination at intervals not to exceed six months except that each source designed for the purpose of emitting alpha particles shall be tested at intervals not to exceed three months.

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 or semipermanently mounted or stored on which one might expect contamination to accumulate. Records of leak test results shall be kept in units of microcuries and maintained for inspection by the Commission.

MATERIALS LICENSE

Supplementary Sheet

License Number 13-02249-01

Docket or
Reference No.

CONDITIONS

Amendment No. 33

13. continued

E. If the test required by Subsection A. or C. of this condition reveals the presence of 0.005 microcurie or more of removable contamination, the licensee 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 Commission regulations. A report shall be filed within five (5) days of the test with the U. S. Nuclear Regulatory Commission, Region III, Office of Inspection and Enforcement, 799 Roosevelt Road, Glen Ellyn, Illinois 60137, describing the equipment involved, the test results, and the corrective action taken.

14. This license does not authorize commercial distribution of licensed material under general licenses or exemptions.

15. The licensee shall not use licensed material in or on human beings or in field applications where activity is released except as provided otherwise by specific condition of this license.

16. Experimental animals administered licensed materials or their products shall not be used for human consumption.

17. Pursuant to Sections 20.106(b) and 20.302, 10 CFR 20, the licensee is authorized to dispose of licensed material by incineration provided the gaseous effluent from incineration does not exceed the limits specified for air in Appendix B, Table II, 10 CFR 20. Ash residues may be disposed of as ordinary waste provided appropriate surveys pursuant to 20.201 are made to determine that concentrations of licensed material appearing in the ash residues do not exceed the concentrations (in terms of microcuries per gram) specified for water in Appendix B, Table II, 10 CFR 20.

18. Except as specifically provided otherwise by this license, the licensee shall possess and use licensed material described in Items 6, 7, and 8 of this license in accordance with statements, representations, and procedures contained in applications dated March 20, 1978 and November 17, 1978.

For the U. S. Nuclear Regulatory Commission

Date DEC 19 1978

by Richard K. Engelken
License Management Branch

Division of Fuel Cycle and
Material Safety
Washington, D.C. 20555

FORM NRC-374C
6-75

U. NUCLEAR REGULATORY COMMISSION

Page 1 of 2 Pages

MATERIALS LICENSE

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Supplementary Sheet

License Number 13-02249-01

Docket or
Reference No.

Amendment No. 35

Miles Laboratories, Inc.
1127 Myrtle Street
Elkhart, Indiana 46514

In accordance with letters dated February 6, 1980 and March 10, 1980, License Number 13-02249-01 is amended as follows:

Items 6., 7., 8. and 9. are amended to read:

6. Byproduct, source, and/or special nuclear material	7. Chemical and/or physical form	8. Maximum amount that licensee may possess at any one time under this license
A. Any byproduct material with Atomic Numbers 1 - 83, inclusive	A. Any	A. Not to exceed 100 millicuries per radionuclide except:
		Hydrogen 3 — 6 curies total
		Carbon 14 — 250 millicuries total
		Iodine 125 — 800 millicuries total

9. Authorized use

A. For possession, storage, and use in research and development as defined in Section 30.4(q), 10 CFR Part 30 and for processing, packaging and distribution to persons authorized to receive the licensed material pursuant to terms and conditions of specific licenses issued by the Nuclear Regulatory Commission or any Agreement State.

MATERIALS LICENSE

Supplementary Sheet

License Number 13-02249-01

Docket or
Reference No.

Amendment No. 35

Conditions 10. and 18. are amended to read:

10. Licensed material shall be used only at the locations specified in Part 1, Item 1(b) of the attachment to the licensee's application dated March 20, 1978 and in licensee letters dated November 28, 1979 and February 6, 1980.

18. Except as specifically provided otherwise by this license, the licensee shall possess and use licensed material described in Items 6, 7, and 8 of this license in accordance with statements, representations, and procedures contained in application dated March 20, 1978 and letters dated November 17, 1978, November 28, 1979, February 6, 1980 and March 10, 1980. The Nuclear Regulatory Commission's regulations shall govern the licensee's statements in applications or letters, unless the statements are more restrictive than the regulations.

Date APR 30 1990

For the U. S. Nuclear Regulatory Commission

by Paul R. Fredrickson
Material Licensing Branch
Division of Fuel Cycle and
Material Safety

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

CORRECTED COPY

MILES LABORATORIES

this copy is for your files

License Number 13-02249-02G
Amendment No. 07

In accordance with application dated July 9, 1980, License Number 13-02249-02G is amended in its entirety to read as follows:

Pursuant to the Atomic Energy Act of 1954, as amended; the Energy Reorganization Act of 1974, as amended (Public Law 93-438); 10 CFR Part 30, "Rules of General Applicability to Domestic Licensing of Byproduct Material"; Section 32.71 10 CFR Part 32, "Specific Domestic Licenses to Manufacture or Transfer Certain Items Containing Byproduct Material"; and application dated July 9, 1980; a license is hereby issued to Miles Laboratories, 1127 Myrtle Street, Elkhart, Indiana 46515 to distribute In vitro kits containing up to 10 microcuries of iodine 125 to persons generally licensed pursuant to Section 31.11, 10 CFR Part 31, or equivalent provisions of the regulations of any Agreement State.

This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, as amended, and other applicable rules, regulations, and orders of the U. S. Nuclear Regulatory Commission now or hereafter in effect.

This license does not authorize possession of licensed material.

This license shall expire on June 30, 1986.

FOR THE U. S. NUCLEAR REGULATORY COMMISSION

Paul K. Lohaus

Material Licensing Branch
Division of Fuel Cycle and Material Safety

JUL 17 1981

Date

16507

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

MILES LABORATORIES, INC.

License Number 13-02249-03E

Pursuant to the Atomic Energy Act of 1954, as amended; the Energy Reorganization Act of 1974, as amended (Public Law 93-438); 10 CFR Part 30, "Rules of General Applicability to Domestic Licensing of Byproduct Material"; Section 32.18, 32.19 and 32.20, 10 CFR Part 32, "Specific Domestic Licenses to Manufacture or Transfer Certain Items Containing Byproduct Material"; and letter dated October 15, 1980; a license is hereby issued to Miles Laboratories, Inc., 1127 Myrtle Street, Elkhart, Indiana 46515 to distribute byproduct material as specified in Section 30.71, Schedule B, 10 CFR Part 30, to persons exempt from licensing pursuant to Section 30.18, 10 CFR Part 30, or equivalent provisions of the regulations of any Agreement State.

This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, as amended, and other applicable rules, regulations, and orders of the U. S. Nuclear Regulatory Commission now or hereafter in effect.

This license does not authorize possession of licensed material.

This license shall expire on June 30, 1986.

FOR THE U. S. NUCLEAR REGULATORY COMMISSION

Original Signed By
JOHN R. GUINN

Material Licensing Branch
Division of Fuel Cycle and Material Safety

Date JUN 15 1981

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)

§ 19.1 Purpose.

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

[40 FR 8774]

§ 19.2 Scope.

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

[46 FR 13971]

§ 19.3 Definitions.

[38 FR 22217]

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.

[46 FR 13971]

(d) "License" means a license issued under the regulations in Parts 30 through 35, 40, 60 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.

[38 FR 22217]

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

§ 19.4 Interpretations.

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

[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.

[36 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.

[38 FR 22217]

(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.

§ 19.12 Instructions to workers.

All individuals working in or frequenting any portion of a restricted area shall be kept informed of the storage, transfer, or use of radioactive materials or of radiation in such portions of the restricted area; shall be instructed in the health protection problems associated with exposure to such radioactive materials or radiation, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed; shall be instructed in, and instructed to observe, to the extent within the worker's control, the applicable provisions of Commission regulations

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

§ 19.13 Notifications and reports to individuals.

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

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

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

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

(d) When a licensee is required pursuant to § 20.405 or § 20.408 of this chapter to report to the Commission any exposure of an individual to radiation or radioactive material the licensee shall also provide the individual a report on his exposure data included therein. Such report shall be transmitted at a time not later than the transmittal to the Commission.

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

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

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

(b) During an inspection, Commission inspectors may consult privately with workers as specified in § 19.15. The licensee or licensee's representative may accompany Commission inspectors during other phases of an inspection.

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

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

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

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

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

§ 19.15 Consultation with workers during inspections.

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

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

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

§ 19.16 Requests by workers for inspections.

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

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

38 FR 22217
44 FR 32332
38 FR 22217
38 FR 22217

suant 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 position with the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, who will provide the licensee with a copy of such statement by certified mail, 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).

[38 F.R. 2721]

§ 19.30 Violations.

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

[40 F.R. 8374]

A court order may be obtained for the payment of a civil penalty imposed pursuant to section 234 of the Act for violation of sections 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Act or any rule, regulation, or order issued thereunder, or any term, condition or limitation of any 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.

[38 F.R. 2721]

§ 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.

[40 F.R. 8374]

§ 19.32 Discrimination prohibited.

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

PART 20 STANDARDS FOR PROTECTION AGAINST RADIATION

GENERAL PROVISIONS

PERMISSIBLE DOSES, LEVELS, AND CONCENTRATIONS

PRECAUTIONARY PROCEDURES

WASTE DISPOSAL

RECORDS, REPORTS, AND NOTIFICATION

EXCEPTIONS AND ADDITIONAL REQUIREMENTS

ENFORCEMENT

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

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

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

§ 20.1 Purpose.

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

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

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

§ 20.2 Scope.

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

§ 20.3 Definitions.

(a) As used in this part:

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

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

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

(4) "Calendar quarter" means not less than 13 consecutive weeks nor more than 14 consecutive weeks. The first calendar quarter of each year shall begin in January and subsequent calendar quarters shall be such that no day is included in more than one calendar quarter or omitted from inclusion within a calendar quarter. No licensee shall change the method observed by him of determining calendar quarters except at the beginning of a calendar year.

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

(6) "Government agency" means any executive department, commission, independent establishment, corporation, wholly or partly owned by the United States of America which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the Government;

(7) "Individual" means any human being;

(8) "Licensed material" means source material, special nuclear material, or byproduct 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, 60 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) "Department" means the Department of Energy established by the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565, 42 U.S.C. 7101 *et seq.*) to the extent that the Department, or its duly authorized representatives, exercises functions formerly vested in the U.S. Atomic Energy Commission, its Chairman, members, officers and components and transferred to the U.S. Energy Research and Development Administration and to the Administrator thereof pursuant to sections 104 (b), (c) and (d) of the Energy Reorganization Act of 1974 (Pub. L. 93-438, 88 Stat. 1233 at 1237, 42 U.S.C. 5814) and retransferred to the Secretary of Energy pursuant to section 301(a) of the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565 at 577-578, 42 U.S.C. 7151).

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

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

(1) "Airborne radioactivity area" defined in § 20.203;

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

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

(4) "Survey" defined in § 20.201;

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

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

§ 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 millirems 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	24 × 10⁶	16
7.5	24 × 10⁶	17
10	24 × 10⁶	17
14 to 20	14 × 10⁶	10

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

25 FR 10914

§ 20.5 Units of radioactivity.

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

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

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

(b) [Deleted 40 FR 50704.]

(c) [Deleted 39 FR 23990.]

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.

** PERMISSIBLE DOSES, LEVELS, AND CONCENTRATIONS

44 FR 32252

§ 20.101 Radiation dose standards for individuals in restricted areas.

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

25 FR 10914

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

44 FR 32252

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

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

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

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

25 FR 10914

§ 20.102 Determination of prior dose.

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

44 FR 32252

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

25 FR 10914

(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).

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

** Amended 36 FR 1466.

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

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

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

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

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

(a)(1) No licensee shall possess, use, or transfer licensed material in such a manner as to permit any individual in a restricted area to inhale a quantity of radioactive material in any period of one calendar quarter greater than the quantity which would result from inhalation for 40 hours per week for 13 weeks at uniform concentrations of radioactive material in air specified in Appendix B, Table I, Column 1.[1][2][3] If the radioactive material is of such form that intake by absorption through the skin is likely, individual exposures to radioactive material shall be controlled so that the uptake of radioactive material by any organ from either inhalation or absorption or both routes of intake[4] in any calendar quarter does not exceed that which would result from inhaling such radioactive material for 40 hours per week for 13 weeks at uniform concentrations specified in Appendix B, Table I, Column 1.

(2) No licensee shall possess, use, or transfer mixtures of U-234, U-235, and U-238 in soluble form in such a manner as to permit any individual in a restricted area to inhale a quantity of such material in excess of the intake limits specified in Appendix B, Table I, Column 1 of this part. If such soluble uranium is of a form such that absorption through the skin is likely, individual exposures to such material shall be controlled so that the uptake of such material by any organ from either inhalation or absorption or both routes of intake[4] 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

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

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

[3] Multiply the concentration values specified in appendix B, table I, column 1, by 6.3×10^4 ml to obtain the quarterly quantity limit. Multiply the concentration value specified in appendix B, table I, column 1, by 2.5×10^5 ml to obtain the annual quantity limit for Rn-222.

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

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

25 FR 10914
41 FR 18300
25 FR 10914
41 FR 52300
41 FR 52300
41 FR 29279

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."* [41 FR 52300]

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

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

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

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

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

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

§ 20.104 Exposure of minors.

(a) No licensee shall possess, use or transfer licensed material in such a manner as to cause any individual within a restricted area who is under 18 years of age, to receive in any period of one calendar quarter from radioactive material and other sources of radiation in the licensee's possession a dose in excess of 10 percent of the limits specified in the table in paragraph (a) of § 20.101. [25 FR 10914]

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

(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. [41 FR 52300]

§ 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. [25 FR 10914]

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

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

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

(c) In addition to other requirements of this part, licensees engaged in uranium fuel cycle operations subject to the provisions of 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," shall comply with that part. [46 FR 18525]

§ 20.106 Radioactivity in effluents to unrestricted areas.

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

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

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

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

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

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

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

(i) chemical composition;

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

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

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

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

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

(i) In air at any point of human occupancy; or [29 FR 14434]

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

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

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

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

(d) For the purposes of this section the concentration limits in Appendix "B", Table II of this part shall apply at the boundary of the restricted area. The concentration of radioactive material discharged through a stack, pipe or similar conduit may be determined with respect to the point where the material leaves the conduit. If the conduit discharges within the restricted area, the concentration at the boundary may be determined by applying appropriate factors for dilution dispersion, or decay between the point of discharge and the boundary.

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

29 FR 14434

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

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

46 FR 18525

§ 20.107 Medical diagnosis and therapy.

Nothing in the regulations in this part shall be interpreted as limiting the intentional exposure of patients to radiation for the purpose of medical diagnosis or medical therapy.

§ 20.108 Orders requiring furnishing of bio-assay services.

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

Precautionary Procedures

§ 20.201 Surveys.

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

(b) Each licensee shall make or cause to be made such surveys as 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.

25 FR 10914

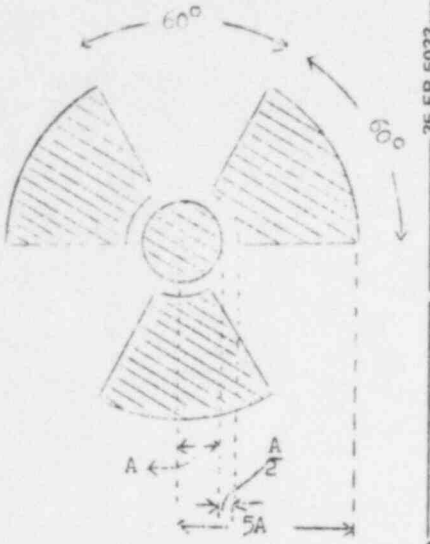
35 FR 5033

§ 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
RADIATION AREA

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

CAUTION
HIGH RADIATION AREA

(2) Each 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 (2) of this paragraph is met.

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

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

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

(iii) Be equipped with control devices such that upon failure or removal of physical radiation barriers other than the source's shielded storage container the radiation level from the source shall be reduced below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour; and visible and audible alarm signals shall be generated to make potentially affected individuals aware of the hazard and the licensee or at least one other individual, who is familiar with the activity and prepared to render or summon assistance, aware of the failure or removal of the physical barrier. When the shield for the stored source is a liquid, means shall be provided to monitor the integrity of the shield and to signal, automatically, loss of adequate shielding. Physical radiation barriers that comprise permanent structural components, such as walls, that have no credible probability of failure or removal in ordinary circumstances need not meet the requirements of this paragraph (c)(6)(iii).

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

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

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

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

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

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

[†] Amended 43 FR 2167

* Amended.

35 FR 5033

35 FR 5033

42 FR 64619

42 FR 64619

tion. No operations other than those necessary to place the source in safe condition or to effect repairs on controls shall be conducted with such source unless control devices are functioning properly. The licensee shall submit an acceptable schedule for more complete periodic tests of the entry control and warning systems to be established and adhered to as a condition of the license.

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

42 FR 54619

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

(d) *Airborne radioactivity areas.* (1) As used in the regulations in this part, "airborne radioactivity area" means (i) any room, enclosure, or operating area in which airborne radioactive 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:

31 FR 10514

CAUTION[1]
RADIOACTIVE MATERIAL(S)

(f) *Containers.* (1) Except as provided in subparagraph (3) of this paragraph, each container of licensed material 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.

43 FR 22171

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

[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 34 FR 19546.

* Department of Transportation.

* Amended

[25 FR 10914]

§ 20.204 Same: exceptions.

Notwithstanding the provisions of § 20.203,

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

[36 FR 5033]

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

[25 FR 10914]

(c) Caution signs are not required to be posted at areas or rooms containing radioactive materials for periods of less than eight hours provided that (1) the materials are constantly attended during such periods by an individual who shall take the precautions necessary to prevent the exposure of any individual to radiation or radioactive materials in excess of the limits established in the regulations in this part and; (2) such area or room is subject to the licensee's control.

[35 FR 5033]

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

[39 FR 17972]

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

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

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

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

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

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

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

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

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

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

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

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

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

TABLE OF EXEMPT AND TYPE A QUANTITIES

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

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

[39 FR 17972]

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

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

[41 FR 16445]

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

[39 FR 17972]

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

[38 FR 22220]

§ 20.206 Instruction of personnel.

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

†Amended 41 FR 16445.

40 FR 26679

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

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

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

45 FR 11971

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, 60, or 70 of this chapter, whichever may be applicable; or

25 FR 10914

(b) As authorized pursuant to § 20.302; or

46 FR 16230

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

25 FR 10914

§ 20.302 Method for obtaining approval of proposed disposal procedures.

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

26 FR 352

*** (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.**

36 FR 23138

(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.

25 FR 10914

§ 20.303 Disposal by release into sanitary sewerage systems.

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

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

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

46 FR 16230

(d) The gross quantity of licensed and other radioactive material, excluding hydrogen-3 and carbon-14, released into the sewerage system by the licensee does not exceed one curie per year. The quantities of hydrogen-3 and carbon-14 released into the sanitary sewerage system may not exceed 5 curies per year for hydrogen-3 and 1 curie per year for carbon-14. Excreta from individuals undergoing medical diagnosis or therapy with radioactive material shall be exempt from any limitations contained in this section.

46 FR 16230

§ 20.305 Treatment or disposal by incineration.

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

§ 20.306 Disposal of specific wastes.

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

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

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

(c) Nothing in this section, however, relieves the licensee of maintaining records showing the receipt, transfer and disposal of such byproduct material as specified in § 30.51 of Part 30 of this chapter; and

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

RECORDS, REPORTS, AND NOTIFICATION

25 FR 10914

§ 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.

45 FR 71781

(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 deleted § 20.304.[1]

*Redesignated 36 FR 23138.

41 FR 18300 — 45 FR 71761 — 41 FR 18360 — 34 FR 7500

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

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

(3) Records of disposal of licensed material made pursuant to §§ 20.302, 20.303, and deleted § 20.304[1] are to be maintained until the Commission authorizes their disposition.

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

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

34 FR 7500 — 41 FR 16445

§ 20.402 Reports of theft or loss of licensed material.

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

41 FR 16445

(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:

34 FR 7500

(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.

41 FR 16445

§ 20.403 Notifications of incidents.

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

37 FR 5906

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

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

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

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

41 FR 16445

(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:

37 FR 5906

(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.‡

29 FR 8822

(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.

45 FR 13434

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

†Amended 42 FR 43965.

[1]Section 20.304 provided for burial of small quantities of licensed materials in soil. Notice of its deletion appears in the Federal Register of October 30, 1980 (45 FR ——).

‡Amended 42 FR 43965.

*Correction

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

(c) 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 levels of radiation or releases of radioactive material in excess of limits specified by 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," or in excess of license conditions related to compliance with 40 CFR Part 190. Each report required under this paragraph shall describe the extent of exposure of individuals to radiation or to radioactive material; levels of radiation and concentrations of radioactive material involved; the cause of the exposure, levels or concentrations; and corrective steps taken or planned to assure against a recurrence, including the schedule for achieving conformance with 40 CFR Part 190 and associated license conditions.

§ 20.406 [Deleted 38 FR 22220.]

§ 20.407 Personnel monitoring reports.

Each person described in § 20.408 of this part shall, within the first quarter of each calendar year, submit to the Director of Management and Program Analysis, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, the reports specified in paragraphs (a) and (b) of this section covering the preceding calendar year.[1] All other persons specifically licensed by the Commission shall, within the first quarter of calendar years 1979 and 1980, submit to the Director of Management and Program Analysis, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, the reports specified in paragraphs (a) and (b) of this section covering the preceding calendar years 1978 and 1979.[2] ‡

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

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

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

[1] Individual values exactly equal to the values separating exposure ranges shall be reported in the higher range.

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

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

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

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

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

(3) Possess or use at any one time, for purposes of fuel processing, fabricating, or reprocessing, special nuclear material in a quantity exceeding 5,000 grams of contained uranium-235, uranium-233, or plutonium or any combination thereof pursuant to Part 70 of this chapter;

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

(5) Possess 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 any one of the following quantities:

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

[2] The Commission will evaluate the data obtained for 1978 and 1979 pursuant to this paragraph, and the benefits derived therefrom and may take action, including publication of notice of proposed rulemaking, to extend or otherwise modify this reporting requirement.

‡ Amended 42 FR 43965.

** Amended 43 FR 29270.

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

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

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

43 FR 44827

§ 20.409 Notifications and reports to individuals.

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

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

38 FR 22220

Exceptions and Additional Requirements

§ 20.501 Applications for exemptions.

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

25 FR 10914

§ 20.502 Additional requirements.

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

25 FR 10914

§ 20.601 Violations.

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

40 FR 8774

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]

APPENDIX B

Concentrations in Air and Water Above Natural Background

(See footnotes on page 20-18)

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
		†	Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Actinium (89)	Ac 227	S	2×10^{-12}	6×10^{-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^{-7}	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^{-2}	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^{-3}	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}

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-18)

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)
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^{-3}	1×10^{-12}	7×10^{-5}
	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^{-5}		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^{-6}	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}

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Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-18)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Cobalt (27)	Co 57	S	3×10^{-6}	2×10^{-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^{-7}	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}
		*	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^{-3}	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
		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}

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-18)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Fermium (100)	Fm 254	S	6×10^{-8}	4×10^{-3}	2×10^{-9}	1×10^{-4}
		I	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^{-3}	1×10^{-10}	9×10^{-5}
		I	2×10^{-9}	3×10^{-3}	6×10^{-11}	9×10^{-5}
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^{-2}	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^{-2}		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^{-9}	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^{-5}

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Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-18)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Iodine (53)	I 134	I	3×10^{-6}	2×10^{-2}	1×10^{-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^{-3}	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 20-18)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
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^{-2}	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^{-2}	3×10^{-8}	2×10^{-3}
	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^{-8}	3×10^{-2}	2×10^{-7}	9×10^{-4}
		I	5×10^{-8}	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^{-5}	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}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-18)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Plutonium (94)	Pu 242	S	2×10^{-12}	1×10^{-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^{-2}	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^{-5}	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^{-3}	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^{-12}	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^{-8}		3×10^{-9}	
Rhenium (75)	Re 183	S	3×10^{-6}	2×10^{-2}	9×10^{-8}	6×10^{-4}
		I	2×10^{-7}	8×10^{-3}	5×10^{-9}	3×10^{-4}
	Re 186	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Re 187	S	9×10^{-6}	7×10^{-2}	3×10^{-7}	3×10^{-3}
		I	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 20-18)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Ruthenium (44)	Ru 97	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	6×10^{-8}	3×10^{-4}
	Ru 103	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	8×10^{-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^{-9}	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}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-18)

Element (atomic number)	Isotope[1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
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^{2}	1×10^{-8}	8×10^{-4}
	Tc 99m	S	4×10^{-3}	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}	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}	8×10^{-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^{-13}	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}
			6×10^{-11}	6×10^{-4}	2×10^{-12}	2×10^{-5}

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Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-18)

Element (atomic number)	Isotope[1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
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}	3×10^{-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}	3×10^{-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}

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

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)
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^{-13}	4×10^{-7}	2×10^{-14}	3×10^{-8}

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

‡4. For soluble mixtures of U-238, U-234 and U-235 in air chemical toxicity may be the limiting factor. If the percent by weight (enrichment) of U-235 is less than 5, the concentration value for a 40-hour workweek, Table I, is 0.2 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8×10^{-8} 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:

$SA = 3.6\times10^{-7}$ curies/gram U (U-depleted $E \geq 0.72$)

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

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

*Amended 37 FR 23319.
**Amended 39 FR 23990; footnote redesignated 40 FR 50704.
***Amended 40 FR 50704.
†Amended 38 FR 29314.
‡Amended 39 FR 25463; redesignated 40 FR 50704.

25 FR 10914
39 FR 23990
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

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^{-12}
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^{-6}

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^{-8}		3×10^{-6}
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^{-8}		2×10^{-6}
If it is known that Sr 90, I 129, (I 125, I 126, I 131, table II only), Pb 210, Ra 226, Ra 228, Cm 248, and Cf 256 are not present		2×10^{-8}		6×10^{-7}
If it is known that (I 129, table II only), Ra 226, and Ra 228 are not present		3×10^{-8}		1×10^{-7}
If it is known that alpha-emitters and Sr 90, I 129, Pb 210, Ac 227, Ra 228, Pa 230, Pu 241, and Bk 249 are not present	3×10^{-8}		1×10^{-10}	
If it is known that alpha-emitters and Pb 210, Ac 227, Ra 228, and Pu 241 are not present	3×10^{-10}		1×10^{-11}	
If it is known that alpha-emitters and Ac 227 are not present	3×10^{-11}		1×10^{-12}	
If it is known that Ac 227, Th 230, Pa 231, Pu 238, Pu 239, Pu 240, Pu 242, Pu 244, Cm 248, Cf 249 and Cf 251 are not present	3×10^{-12}		1×10^{-12}	

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

APPENDIX C

Material	Microcuries
Americium-241	.01
Antimony-122	100
Antimony-124	10
Antimony-125	10
Arsenic-73	100
Arsenic-74	10
Arsenic-76	10
Arsenic-77	100
Barium-131	10
Barium-133	10
Barium-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

35 FR 6425

Material	Microcuries
Osmium-191m[1]	100
Osmium-191	100
Osmium-193	100
Palladium-103	100
Palladium-109	100
Phosphorus-32	10
Platinum-191	100
Platinum-193m	100
Platinum-193	100
Platinum-197m	100
Platinum-197	100
Plutonium-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	.01
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

35 FR 6425

35 FR 6425

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

45 FR 71761

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

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

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

* Amended 36 FR 16898

** Amended 39 FR 23990

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) 337-5000	‡ (215) 337-5000
II Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, *** Puerto Rico, South Carolina, Tennessee, Virginia, Virgin Islands, and West Virginia	† Region II, USNRC Office of Inspection and Enforcement 101 Marietta Street Suite 3100 Atlanta, Georgia 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) 932-2500	** (312) 932-2500
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)465-8100	**** (817)465-8100
V Alaska, Arizona, California, Hawaii, Nevada, Oregon, Washington, and U.S. territories and possessions in the Pacific	Region V, USNRC Office of Inspection and Enforcement 1990 N. California Blvd. Suite 202 Walnut Creek, Calif. 94596	** (415) 943-3700	** (415) 943-3700

40 FR 42557

*Amended 41 FR 55851.

†Amended 43 FR 32741.

‡ Amended 43 FR 52201.

** Amended 44 FR 63515.

*** Amended 45 FR 18905

≫ ****Amended 46 FR 18015

MILES LABORATORIES, INC.
Radiation Control Office
Isotope Forms

Isotope Form #	Title	Miles Form #
1	Appl. for Isotope Procurement	4.090
2	Statement of Training	4.102
3	Procedure for Filling Out Isotope Per. Form	4.914
4	Occ. Ext. Rad. Exposure	4.103
6	Film Badge Request	4.867
7	Protocol for Radioisotope Use	P.363
8	Daily Inventory Form	4.196
9	Radioisotope Disposal Record	4.395
10	Quarterly Inventory Form	4.398
14	Determination of Urinary Tritiated Water	4.922
16	Description of Sealed Source	4.400
18	Area Survey/Wipe Test Report - Gamma	
19	Area Survey Report (G-M Survey)	
20	Area Survey/Wipe Test Report - Beta	
21	Air Sampling - Iodine-125	
22	Thyroid Monitoring	4.990

Miles Laboratories, Inc.
Radiation Control Office
Isotope Form-1

Committee
Ref. No._____

APPLICATION FOR RADIOISOTOPE PROCUREMENT

1. Names of personnel to use isotope:

_____ Dept._____ Phone_____

_____ Dept._____ Phone_____

_____ Dept._____ Phone_____

_____ Dept._____ Phone_____

_____ Dept._____ Phone_____

All persons named must have submitted Isotope Forms 2, 4 and 6.

2. Radioisotope:_____millicurie(mCi)amount:_____

3. Product Description:_____

4. Vendor:_____

5. Location of use:_____ Bldg._____ Room No._____

6. Area Survey Reports/Wipe Tests are current and have been submitted to Radiation Control Office: Yes_____ No_____.

7. Protocol No._____ for radioisotope project.

8. Signed:_____ Date:_____
(Must be signed by your Area Radiological Control Supervisor)

9. Send completed forms to Kenyon D. Yoder. NOTE: An application should be submitted for each isotope and/or chemical form requested.

- -

DO NOT FILL IN

Approved-Denied _____ Date_____
Radiological Control Officer

Remarks _____

_____

Film Badge or Dosimeter: Yes_____ No_____ Miles Lot Number_____

Form #4.090 (Rev. 12-78)

Miles Laboratories, Inc.
Isotope Form-2 (11/70) STATEMENT OF TRAINING AND AGREEMENT

1. Name _____ Dept. _____

2. Type of Training:

TYPE	WHERE TRAINED	DURATION	FORMAL COURSE (circle one)		ON THE JOB (circle one)	
a)principles and practices of radiation protection			yes	no	yes	no
b)radioactivity measurement, monitoring techniques, and instruments			yes	no	yes	no
c)mathematics and calculations basic to use and measurement of radioactivity			yes	no	yes	no
d)biological effects of radiation			yes	no	yes	no

3. Formal courses (list all courses pertaining to isotopes):

Title of Course	Where Trained	Duration	Course Content

4. Experience (actual use of isotopes)

Isotope	Maximum Amount (mc)	Where experience gained	Duration	Type of Use

5. Remarks: (List any publications on reverse)

6. Supervisor's Statement: I have provided the below named individual with copies of 1)the AEC license held by Miles Laboratories, Inc., 2)the current radiological control handbook for Miles Laboratories, Inc., and 3)10CFR20, "Standards for Protection Against Radiation", and verify that he has been advised of and understands the appropriate portions of these documents.

Date _____ Signed _____

7. Statement of Agreement: The below named individual signifies that he has read and is willing to abide by the Miles Laboratories, Inc., regulations governing the use of radioisotopes and other sources of ionizing radiation. The undersigned agrees to comply strictly with all such rules and regulations and hereby waives any right to recourse against Miles Laboratories, Inc., for any damage whatsoever resulting from any failure to fully conform with said regulations.

Date _____ Signed _____

Isotope Form # 3

PROCEDURE FOR FILLING OUT ISOTOPE PERSONNEL FORMS

Note: The attached isotope forms must be completed and forwarded to the Radiological Control Officer before any person can begin working with radioactive material.

Form 2:

2. TYPE OF TRAINING: Circle yes only if previous training has been in a formal academic course or if you have previously had experience working with isotopes. If you have had such training (in any of the four areas specified) list the place (school or company) and duration of training.

3. FORMAL COURSES: Fill in if you have had formal academic training.

4. EXPERIENCE: List the isotope(s) you have worked with, the maximum amount used at any one time, where the work was done (school or company), how long you worked with the isotope, and the type of study (drug tracer, etc.).

6. SIGNATURE: The Area Radiological Control Supervisor for your laboratory.

7. Sign and Date the sheet.

Form 4:

1, 2, 3, and 4 - fill in.

5. EXPOSURE HISTORY: List all previous employment(s) which involved exposure to radiation and the type of radiation employed (isotope, non-medical x-ray, etc.).

6. The date(s) of the above employment(s).

7. The dates of exposure period(s).

12. Sign and Date the sheet.

8, 9, 10, 11 and 13 will be filled in by the Radiological Control Officer.

Form 6:

Complete only if exposure will be to hard beta over 1.5 MeV, x-ray, or gamma radiation.

Kenyon D. Yoder
Radiological Control Officer

NOTE: It is Company policy that pregnant women are not allowed to work with radioactive materials.

Miles Laboratories, Inc.
Radiation Control Office
Isotope Form-4

OCCUPATIONAL EXTERNAL RADIATION EXPOSURE HISTORY

IDENTIFICATION

1. Name (Print - Last, First, Middle)	2. Social Security Number
3. Date of Birth (Month, Day, Year)	4. Age in Full Years (N)

OCCUPATIONAL EXPOSURE - PREVIOUS HISTORY

5. Previous Employments Involving Radiation Exposure-Name and Address	6. Dates of Employment (from - to)	7. Periods of Exposure	8. Whole Body (REM)	9. Insert one: Record or Calculated

10. Remarks:

11. Accumulated Occupational Dose - Total

12. Certification: I certify that the exposure history in columns 5, 6 and 7 is correct and complete to the best of my knowledge and belief.

Employee's Signature

Date

13. Calculations - Permissible Dose Whole Body:

(A) Permissible Accumulated Dose = 5(N-18) = _____ REM

(B) Total Exposure to Date (Item 11) = _____ REM

(C) Permissible Dose = _____ REM

14. Miles Laboratories, Inc.
Name of Licensee

Miles Laboratories, Inc.
Radiation Control Office
Isotope Form-6

FILM BADGE REQUEST FORM

The following information is required for the assignment of a film badge to Miles Laboratories personnel for radiation monitoring.

Date____________________

Full Name____

Social Security Number________________________________

Date of Birth______________________________________

Department____________________ Monthly________ Weekly________

Department Account Number______________ Phone Number______________

Immediate Supervisor__________________________________

Type of Radiation to which you will be exposed:

________ Gamma: radioisotope which will be used.________________

________ Hard Beta: radioisotope which will be used.________________
(NOTE: Film badges will not be issued to those persons using only H-3, S-35, C-14, or Ca-45 because badges are not sensitive to low energy beta emitters.)

________ Permanent assignment, or temporary____________________

Have you previously been occupationally exposed to radiation at another place of employment? Yes_____ No_____. If Yes, where and under what circumstances?

____

____

Date on which you wish film badge service to begin ____________________

APPROVED:________________________________ Date________________
(Must be signed by your Area Radiological Control Supervisor)

- -

DO NOT FILL IN

Film Badge Assignment

Badge Number________________

Date Assigned________________

Type	Frequency
____ Dosimeter	
____ Beta	____ Monthly
____ Gamma, Total Body	
____ Gamma, Ring	____ Other

APPROVED:

____
Radiological Control Officer

PROTOCOLS FOR THE USE OF RADIOACTIVE MATERIALS

A protocol must be submitted for review by the Isotope Committee. Users cannot receive or use radioactive materials without an approved protocol for their use. After receiving the completed application, the Isotope Committee will review and give its approval which will be based upon the adequacy of the experience and ability of the applicant to cope with hazards involved, the adequacy of equipment and facilities, and the thoroughness and attention given to safety procedures.

After approval, the Area Radiological Control Supervisor will receive a copy of the approved protocol with the user project number. This number will need to be used on the isotope procurement form for all subsequent requisitioning of isotopes for the project. It will be his/her responsibility to see that all personnel under his/her direction observe safe procedures and make proper use of all personnel and laboratory monitoring facilities available. Safety procedures not followed will be cause for denial of isotope procurement until situation is corrected.

The following guidelines should be used in preparing protocols:

1. A separate protocol should be submitted for each completely different study.

2. One protocol is sufficient for several compounds if the compounds are to be used in the same study under essentially identical conditions.

3. Responses should be concise and definitive of the project. Protocols which are too general will be returned for clarification.

4. Projects relocated to new work areas and other significant changes will require an amendment to the approved protocol detailing these changes.

Miles Laboratories, Inc.
Radiation Control Office
Isotope Form-7 (2 of 3)

Project No._____

PROTOCOL FOR RADIOISOTOPE USE

Department/
Section Name:_____ Bldg./Room:_____

Project Title:_____

Staff member in charge:_____ Phone:_____

Principal User of radioactive material:_____

List all other users who will participate in this project:_____

_____

_____

Radioisotope to be used	Chemical form	Physical form	Intended Quantity millicuries

Sealed Sources (permanently encapsulated) Yes_____ No_____

I affirm that the foregoing facts are correct to the best of my knowledge and that I shall conduct and/or supervise the described work with full regard for the safety of those engaged in the work and of the general public. I have received and read a copy of the Radioisotope Guidelines Handbook, describing the responsibilities, procedures, and regulations governing the safe use of radioisotopes at Miles Laboratories, Inc. and understand that I am to abide by the policy contained therein.

Signed_____, Applicant Date_____

The Miles Radioisotope Committee (grants - denies) permission to proceed with this project, obtain material requested herein and to use it as described in this application.

Signed_____, R.C.O. Date_____
Isotope Committee

DESCRIPTION OF RADIOISOTOPE USE

I. DESCRIPTION OF PROJECT
Provide a brief description of the experiment and outline purpose and/or objectives.

II. DURATION OF EXPERIMENT
An estimate as to duration of the total project and time involved in particular phases should be made (such as time involved from tagging animals to subsequent sacrifice or the time an isotope would be used in a specific experiment).

III. WORK AREAS
List the laboratories or areas where work involving the radioisotope will be performed. Comment on the equipment, facilities and general condition of the work areas including such things as interface with other work, if any, being performed in the area.

IV. USE OF ANIMALS
List kind of animals to be used, approximate number per experiment, dose in microcuries/animal, where tagged animals will be housed and how long.

V. USE OF ISOTOPES
a. Tracer Uses
If a stock solution of a radioisotope is to be diluted or separated into aliquots, this process should be described giving 1) solvent, 2) subsequent aliquot amounts, and 3) facility where this is to be performed (hood, etc.). All aliquots should be properly marked and labeled.

b. Production, Labelling, or Purification
Will tritiated water, carbon dioxide, or airborne iodine occur during the use of this material.

c. Sealed Sources
A description of how the source is to be secured, shielded and the dose rate expected in the general area of use.

VI. HANDLING PROCEDURES
Handling procedures such as use of gloves, lab coats, shielding, tongs, marking tape, absorbent paper, etc. should be specified.

VII. STORAGE AREAS
Specify where (room number and/or refrigerator, hood, cabinet, etc.), type of container (if shielding is to be used), and in what form the isotopes are to be stored.

VIII. RADIATION SURVEYS
What instruments are available to be used for surveying the lab and personnel during the experiment. Gamma emitters - G-M Survey Meter, wipe test and film badges. Beta emitters - surface wipe test. Indicate frequency and individual primarily responsible for conducting survey.

IX. DESCRIPTION OF ALL CHEMICAL AND BIOLOGICAL WASTE DISPOSAL
Indicate expected radioactive waste products, solids, animals, aerosols, particulates and chemical forms of liquid.

PURCHASED

Isotope_____

Chemical Form_____

Vendor_____

Date_____

Activity_____millicuries

RECEIVED

Requisitioned by_____

Miles Inventory No._____

Storage Location_____

Date of Spec. Act. Determination_____

Specific Activity_____

Isotope Form # 8

ISOTOPE INVENTORY

Date of Use	Quantity Used	Quantity Remaining	mCi Used	mCi Remaining	mCi Remaining After Correcting for Disposal or Decay
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					

Isotope Form # 9

RADIOISOTOPE DISPOSAL RECORD

Date:_____ Isotope:_____

User's name and department:_____

Identification of waste container:_____

Type of waste (circle one): liquid combustible solid non-combustible solid

Description of contents:_____

Chemical contents:_____
(principal solvent, reagent, and/or most toxic form)

Radioactivity of material:_____(microcurie)
(show calculations below or indicate basis of estimation)

DO NOT WRITE BELOW COLLECTION AREA USE ONLY

Date received from user_____ By_____

*Method of disposal:_____

Date of disposal:_____

Radioactivity at time of disposal (μCi):_____

Contents verified by:_____Packaging verified by_____

*Indicate number assigned to barrel removed by Nuclear Engineering Co., Inc., or incineration in Miles crematorium (Bldg. 9).

Form 4.395 (Rev. 8-80)

Isotope Form # 10

Isotope Inventory

Name of Area Radiological Control Supervisor: _____

Area or Department of Supervision: _____

Inventory at the end of the _____ Quarter, 19___

Inventory of Radioactive Compounds:

	Millicurie (mCi) Quantity	
Isotope Label	Original Material	Stored Waste
^{3}H	_____	_____
^{14}C	_____	_____
^{32}P	_____	_____
^{51}Cr	_____	_____
^{57}Co	_____	_____
^{59}Fe	_____	_____
^{125}I	_____	_____
^{131}I	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Inventory of Permanently Encapsulated Sealed Sources:

Radionuclide	Activity (millicurie)
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Date: _____ Signed by: _____

FORM # 4.398 (REV. 1/74)

Isotope Form # 14

DETERMINATION OF URINARY TRITIATED WATER

NAME OF USER _____

DESCRIPTION OF USE OF TRITIUM:

METHOD OF MONITORING:

Before handling tritium, the prospective user will collect a urine specimen which will serve as background for specimens collected during tritium use.

During the period of tritium handling, the tritium user will collect 24-hour total, pooled urine samples, record below each 24-hour volume and submit to the radiation control office, a 5 ml aliquot of each 24-hour urine and the background specimen. One ml of each 24-hour sample will be transferred to a Wheaton vial containing 14 ml XDC scintillator (8% w/v naphthalene, 1% PPO, 0.05% dimethyl POPOP in a 1:3:3 mixture of xylene, dioxane, ethylene glycol monoethyl ether) and counted three times in a Packard TriCarb Model 3375 for 5 minutes or to 10,000 counts.

Exposure of workers to air containing HTO vapor at the NRC recommended occupational MPC level will produce tritium activity of about 28 μCi/liter or 28 nCi/ml (62,160 DPM/ml) of urine.

COUNTING DATA:

Sample No. & Date of Collection	Vol/24 hr Urine	Urine CPM/ml	Counting Efficiency	Urine DPM/ml	Urine nCi/ml	Total ^{3}H Excreted

Date _____ Monitored by _____

Isotope Form # 16

DESCRIPTION OF SEALED SOURCE

ISOTOPE [ ] MC QUANTITY [ ]

LOCATION _____ USER _____

DESCRIPTION:

_ _ _ _ _DO NOT _WRITE BELOW _ _ _ _

SEALED SOURCE NUMBER [ ]

LEAK TEST REQUIRED _____

FREQUENCY _____; MONTHS:_____

METHOD OF LEAK TESTING:

Isotope Form # 18

AREA SURVEY REPORT
(Wipe Test)

EXAMPLE

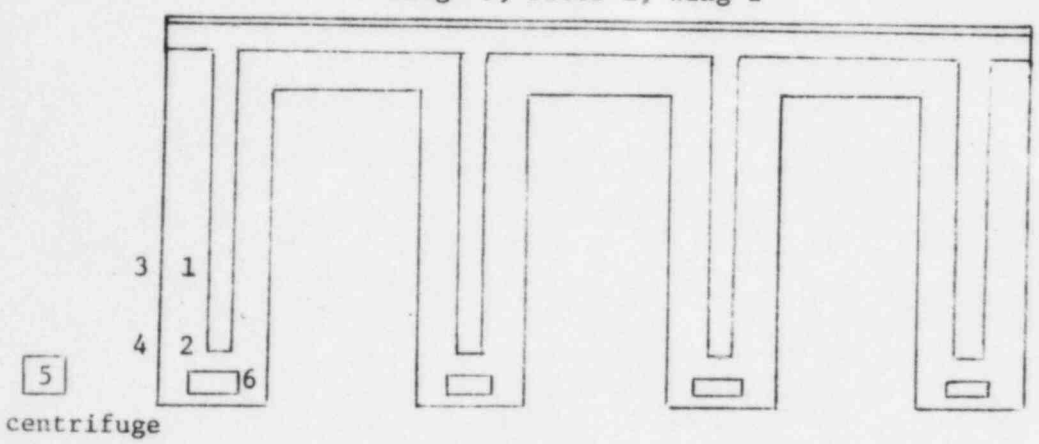
Procedure:

Each numbered area, and those others which may be appropriate at a given time, will be wipe tested monthly. A 25 mm.-50 mm. (1-2 inch) diameter Whatman No. 1 filter paper disk moistened with 0.9% sodium chloride is wiped across a representative area (approximately 100 cm^2). The paper disk is placed into bottom of disposable plastic counting tube and placed in counting well of Gammacord II and counted at optimum counting position. Each sample is counted three times for a minimum of five minutes and recorded below. A wipe test is defined as negative unless the observed count rate (in CPM) is more than three times background count rate. Any area found to be contaminated is decontaminated by an approved procedure. Resurvey the area after cleaning and record in table below.

Room Layout:

Room Number: 2107 (APRD)

Bldg. 9, Floor 1, Wing 2



Area	Isotope	Before	After*	Area	Isotope	Before	After*
Background		20 CPM	22				
1	^{125}I	29		7			
2	"	30		8			
3	"	22		9			
4	"	21		10			
5	"	35		11			
6	"	124	41	12			

*after decontamination with soap & water, count-off

DATE: _____ SIGNED: _____

Isotope Form # 19

AREA SURVEY REPORT
(G-M Survey Reading)

EXAMPLE

Procedure:

Each designated area is to be surveyed weekly with a geiger counter containing an end window thickness of no more than 1.4 - 2.0 mg/cm^2. This instrument must have been calibrated against a known I-125 or I-129 reference source. Indicated readings will be recorded, while actual exposure will be determined from the calibration factor for the probe.

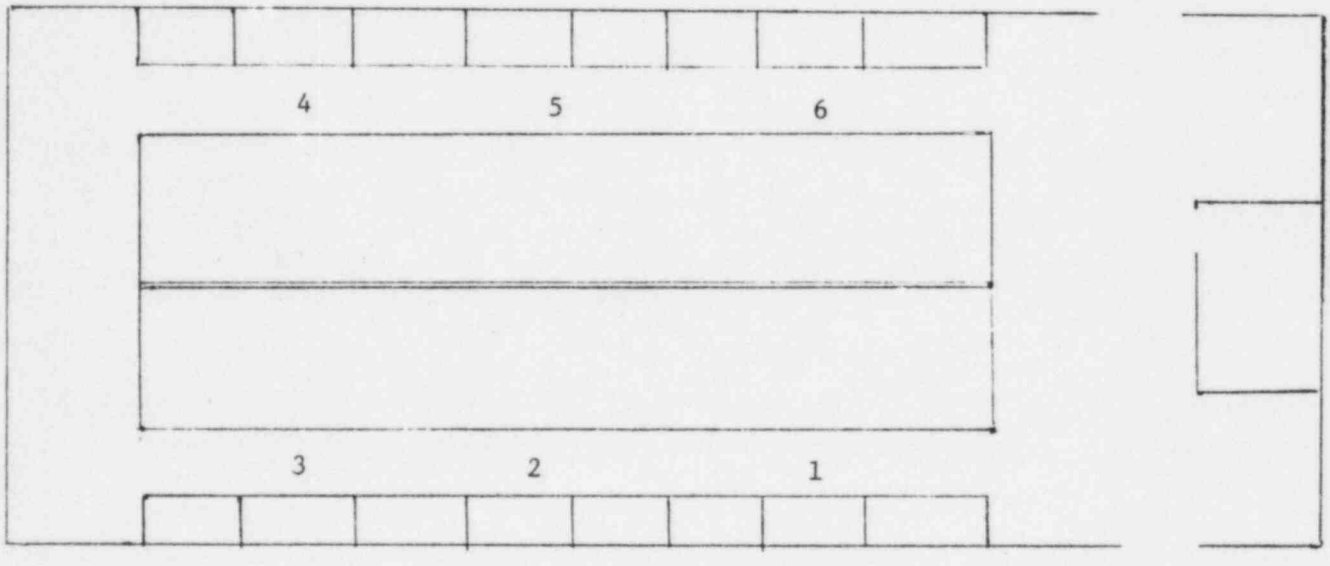
In searching for contaminated surfaces, the probe should be moved slowly over the surface approximately 1 inch above the surface (to prevent contamination of the probe). Areas indicating contamination above background will require a subsequent wipe test.

General area surveys are best performed by holding the detector away from the body at waist level and tracing a systematic path through the area, noting any rise in radiation level and marking these spots either directly with chalk or on the diagram below. Radiation levels above background will require determination of direction of source and reason for elevated readings. Background readings away from work areas will normally range from 0.01 - 0.02 millirem/hour (mR/hr).

Mishawaka Plant

Room Layout:

Room Number: Inst. Prod. Test Area



Instrument Calibration: direct readout

Area	Indicated reading	Actual exposure	Distance from source	Type of source	Recommended correction
Background	0.03 mR/hr	same	- -	- - -	- -
1	"	"	2 ft.	^{129}I & ^{137}Cs	None
2	"	"	"	"	"
3	"	"	"	"	"
4	"	"	"	"	"
5	"	"	"	"	"
6	"	"	"	"	"

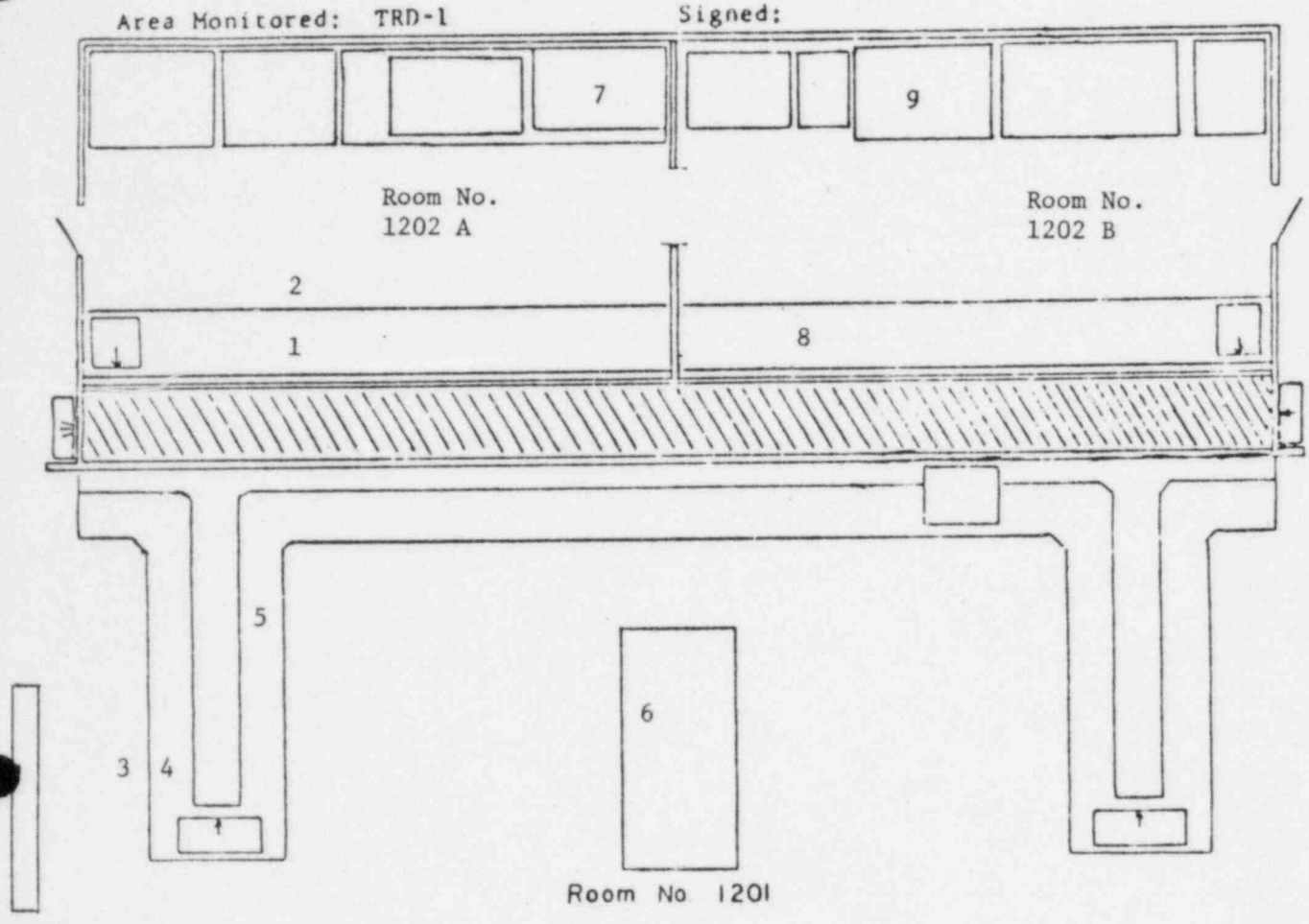
DATE: _____ SIGNATURE: _____

Isotope Form # 20

EXAMPLE

Radioisotope Area Survey Report Date:

Area Monitored: TRD-1 Signed:



Each numbered area and others which may be appropriate at a given time, will be wipe tested as specified. A 5 cm. diameter Whatman No. 1 filter paper disc, or one cut to fit a scintillation vial, is moistened with 50% ethanol and wiped accross each specified area covering a sampling of 100 cm^2. The paper is placed in a scintillation vial containing the appropriate liquid scintillation fluid. The samples are counted three times in a liquid scintillation counter for 5 minutes or to 10,000 counts in a configuration such as to detect both ^3H and ^{14}C. An appropriate blank from a noncontaminated area will be counted and compared to sample areas. A wipe test will be defined as negative unless the observed count rate is in excess of three times the background count rate. Contaminated areas are to be scrubbed down with soap and water, commercial decontamination preparations, 50% ethanol, or other solvents appropriate to the contaminant. The decontaminated areas are recounted and recorded on this report. Retain a copy of this report and send original to the Radiation Control Office.

Area	^3H ^{14}C CPM Before		^3H After[a]	Area	^3H ^{14}C CPM Before		^3H After[a]
BK	54	47	38	5	63	59	-
1	139	52	52	6	84	78	-
2	59	44	-	7	210	56	58
3	55	48	-	8	354	49	67
4	72	53	-	9	102	51	40

a. after decontamination with ethanol, count-off & water

Isotope Form # 21

AIR SAMPLING - I-125

Procedure: Date: _____

Evaluation of concentration of airborne radioactivity is performed by drawing a measured amount of air through a system of charcoal filters. Charcoal filters ranging in size from 25 mm.- 47 mm. are acceptable. After the collection period, the filter paper may be rolled and placed in the bottom of a disposable counting tube. Care should be taken to count all samples at the optimum counting position for the detector. Gammacord I & II contain a 2" NaI crystal and will not efficiently count a paper disk larger than 2 inches. The counting efficiency of the instrument needs to be determined against a known (NBS traceable) quantity of I-125 for accurate determination of the activity level. Air volume through the filtering system needs to be determined in ml/min. The sample should be counted to give a statistical accuracy of ±2%.

CALCULATION OF CONCENTRATION:

$$\frac{\text{CPM SAMPLE - CPM BACKGROUND}}{\text{FLOW RATE (ml/min) X SAMPLING TIME (no. of min) X INST. EFFICIENCY (\%E) X } \frac{2.22 \times 10^6 \text{ DPM}/\mu\text{Ci}}{(2.22 \times 10^6 \text{ DPM}/\mu\text{Ci})} = \mu\text{Ci/ml}$$

The maximum permissible airborne concentrations for I-125 as listed in 10CFR20 are as follows:

Restricted areas (occupational): 5×10^{-9} µCi/ml
Unrestricted areas (non-occupational): 8×10^{-11} µCi/ml

Licensees are allowed to average airborne concentrations in non-occupational areas over a period of one year. When air levels are greater than maximum limit, monitoring should continue until levels are found to be less than the maximum limit.

Description of Areas:

Area 1: _____

Area 2: _____

Area 3: _____

Area 4: _____

Data:

Date of last Iodination: _____ Gammacord Efficiency: _____

Flow rate _____ (ml/min.) Background CPM: _____

Sampling time _____ (min.)

Room Monitor:

Area	Time	Gross CPM	Net CPM	Found Conc'n (µCi/ml)	Found Concentration ÷ 5×10^{-9} µCi/ml

Exhaust Stack Monitor:

Area	Time	Gross CPM	Net CPM	Found Conc'n (µCi/ml)	Found Concentration ÷ 8×10^{-11} µCi/ml

16507

SIGNATURE: _____

Miles Laboratories, Inc.
Radiation Control Office
Isotope Form-22

THYROID MONITORING

METHOD OF MONITORING:

Take one of the appropriate mock I-125 standards and place in thyroid phantom. Position 2" diameter NaI scintillation detector probe against surface and count for 1 minute. Remove standard and determine background level of phantom. Record standard counts. To measure an individual's thyroid, first count a clean area of body (e.g. forearm) and record as background. Then position detector probe against neck at position closest to right lobe of thyroid. Count one minute, record and then repeat procedure for left lobe.

ACTION LEVELS:

0.010μCi increase over previous weekly measurement requires an evaluation of work activities.
0.12μCi total thyroid burden is action point under NRC Regulatory Guide 8.20.
0.72-0.8μCi total thyroid burden is a reportable incident to NRC.

CALCULATION:

$$\text{Activity in Thyroid } (\mu Ci) = \text{Activity of standard } (\mu Ci) \times \frac{\text{Net CPM of Thyroid}}{\text{Net CPM of Standard}}$$

COUNTING DATA:

Calibration: _____μCi Activity of standard (^{125}I)(^{129}I)(mock ^{125}I) = _____Net CPM.
[Circle One]

User Background: _____CPM

User Name	Lobe	Gross CPM	Net CPM	Burden(μCi)	Remarks

Signature _____ Date _____

Form No. 4.990