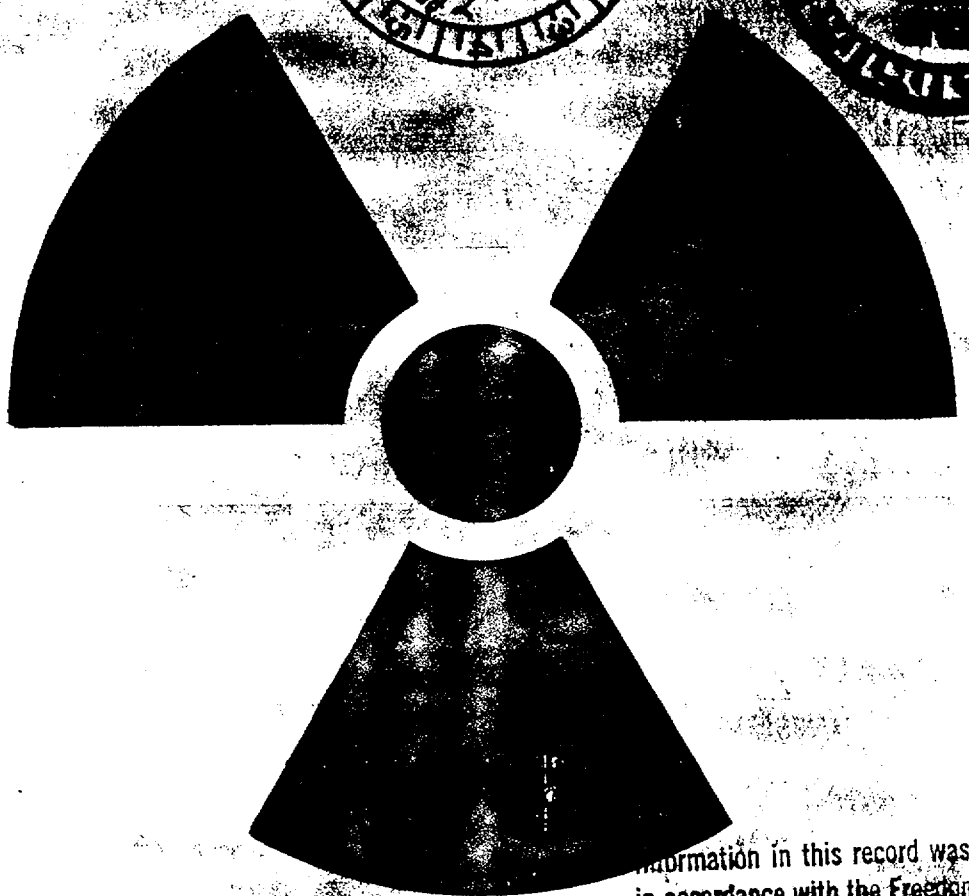
RADIA



PRINCETON UNIVERSITY
RADIATION SAFETY COMMITTEE

ITEM # 2

RADIATION SAFETY GUIDE

Second Edition

June 1965

(Updated February 1966)

PRINCETON UNIVERSITY

Radiation Safety Committee

(First Edition June 1962)

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I. RADIATION SAFETY PROGRAM

A. Staff And Raison D'Etre

In view of the increasing use of radiation-producing machines and radioisotopes in the teaching and research programs of Princeton University, President Robert F. Goheen has directed, on the recommendation of the University Research Board, that a University Radiation Safety Committee be formed to be responsible for instituting and maintaining a University-wide Radiation Safety program. The purposes of the program are:

1. to minimize the hazards to personnel and property attendant to the use of such machines and materials insofar as is practicable, and

2. to insure compliance with State and Federal laws and regulations covering the use of such machines and materials.

B. Ultimate Responsibility

Departmental chairmen and laboratory directors shall be responsible for the ultimate enforcement of the recommendations of this Committee and for co-operation with the Committee.

C. Committee Membership

The committee shall include one representative from each Department or major project of the University engaged in a program (or programs) involving possible radiation hazards as determined by the Committee and one representative from the University Administration. Each representative shall be appointed annually to the Committee, on the basis of recommendations to the President by the Chairman or Director concerned and, preferably, the representative shall be chosen from the research staff of the Department or project concerned.

D. The Health Physics Group.

The Committee is granted the authority to establish a Health Physics Group within the University to implement the policies and decisions of

said Committee and to be responsible to said Committee; the Head of such a Health Physics Group is to be a member and serve as secretary of the University Radiation Safety Committee. The names of members of the University Radiation Safety Committee are listed in Appendix A.

E. Health Physics Group Responsibilities

Among the responsibilities of the Health Physics Group are:

1. to provide advice and assistance in the acquisition of dosimetry equipment,

2. to provide first echelon maintenance and periodic calibration of survey equipment,

3. to maintain all centralized records pertinent to the radiation safety program,

4. to inspect and survey laboratories where radiation hazards may exist,

5. to administer a radioactive waste disposal program,

6. to provide temporary storage of radioactive materials,

7. to provide consultation services related to radiation,

8. to develop and refine radiation detection, shielding and health protection techniques,

9. to provide assistance and advice in emergency decontamination procedures,

10. to represent the University on public policy making organizations concerned with problems of radiation safety,

11. to investigate radiation incidents,

12. to advise on the shipment of radioactive materials,

13. to provide leak tests for sealed radioactive sources,

14. to administer the acquisitions of radioisotopes under the provisions of the University's Licenses.

II. RESPONSIBILITY FOR COMPLIANCE WITH UNIVERSITY RADIATION SAFETY REGULATIONS

A. Responsibilities

The individual members of the Health Physics Group shall exercise only inspection and advisory functions in relation to the University teaching and research staff. If in the opinion of the Health Physics Group an improper practice exists, the Health Physics Group shall recommend a correctional procedure. Should no steps be taken to correct the suspect practice, the head of the Health Physics Group will undertake discussions with the Departmental Chairman or Director. Should still no action follow, the suspect practice will be referred to the University Radiation Safety Committee for action.

Topics related to the radiation safety program may be brought before the University Radiation Safety Committee by either Departmental Chairman or Director, or by the secretary of the Radiation Safety Committee, who shall entertain suggestions from all interested parties. Departmental Chairmen and Laboratory Directors shall be responsible for the ultimate enforcement of the recommendations of this Committee and for cooperation with the Committee.

B. The Radiation Safety Guide

This Radiation Safety Guide, prepared under the supervisor of the U.R.S.C., sets forth the *modus vivendi* of all those who want to use

any source of ionizing radiation in this University. Most of the regulations included are already binding upon the University by reason of their enactment into various governmental radiation safety codes or contractual agreements (See Appendix C for a listing). These regulations are designed to facilitate control of activities involving possible radiation hazards. Every attempt has been made to include in this guide sufficient information to insure compliance with all regulations. In cases of doubt the reader is advised to consult the basic regulations and/or the Health Physics Officer.

This Guide has been prepared to protect individuals, the population at large and the University from radiation damage and law suits. It attempts to do this with the least possible interference with teaching and research.

C. Definitions

1. "Airborne Radioactivity Area" - is any room, enclosure, or operating area in which radioactive materials are airborne and exist or are likely to exist, in concentrations in excess of the amounts specified in Table 1 Appendix B, or in which they exist in concentrations which when averaged over the number of hours in any week during which individuals are in the area exceeds 25 per cent of the amount specified above.

2. "Director of a Laboratory" - refers to one who is designated by the University Administration as the individual who has immediate supervisory responsibility over all projects conducted within a unified frame work of research. "Director of a Laboratory" also includes "Departmental Chairman".

3. "Health Physics Officer" - shall refer to either the Head of the Health Physics Group or a certain person so designated by the Head of the Health Physics Group (See Appendix A).

4. "High Radiation Area" - means any area, accessible to personnel, in which there exists radiation,at such levels that a major portion of the body may receive in any one hour a dose in excess of 100 millirems.

5. "Human Use" - means the internal or external administration of radioactive material or the radiation therefrom, to human beings.

Note: Any such contemplated use shall be first discussed with the Radiation Safety Committee who shall make a recommendation to the University Research Board. Prior approval of both the U.S.A.E.C. and the State of New Jersey must be also secured in the form of an ammendment to our Licenses.

6. "Radiation Area" - means any area, accessible to personnel, in which there exists radiation,at such levels that a major portion of the body may receive in any one hour a dose in excess of 5 millirem, or in any five consecutive days a dose in excess of 100 millirems.

7. "Radioactive Material Area" - any room or area in which there is present radioactive materials in such quantities that a "Caution Radioactive Materials" label is required in accordance with Appendix I.

8. "Responsible Investigator" - refers to the individual who is immediately responsible for the conduct of a research project involving the use of a source of ionizing radiation. This implies a faculty or research position and previous experience with "Sources of Radiation".

9. "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.

Note: "Restricted Area" includes all "Radiation Areas", "Radioactive Material Areas" and certain other areas which may be so defined by the University Radiation Safety Committee.

10. "Sealed Source" - means any radioactive source material encased in a capsule designed to prevent leakage or escape of the radioactive material and to be used unopened.

11. "Sources of Radiation" - refers to radioisotopes, radioactivated materials and radiation producing machines.

12. "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. It should be noted that areas outside the control of the University by virtue of ownership are classified as unrestricted.

13. "10 CFR 20" - refers to Title 10 of the Code of Federal Regulations Part 20. Title 10 is the "Atomic Energy Act" which established the A.E.C. Part 20 is one part or section of Title 10 and is entitled "Standards for Protection Against Radiation". Part 30 is also of general interest and is entitled "Licensing of By-Product Material".

D. In the Radiation Safety Regulations, which follow, the terms "shall" and "must" are used in the obligatory sense, "should" is used in the permissive sense.

III. WHO MAY POSSESS SOURCES OF RADIATION

A. Those persons who qualify under the definition of Responsible Investigator may apply for authorization to possess and use "Sources of Radiation."

B. Under certain circumstances persons not qualifying as "Responsible Investigators" may obtain a "Limited Possession Number" for very small amounts of radioactive materials.

C. Specific Instructions for obtaining the various authorizations appear in the following section. For authorization to possess Radiation

Producing Equipment and Machines consult Section XII.

IV. HOW TO ACQUIRE RADIOISOTOPES OR IRRADIATIONS

A. Authorization Numbers

1. The applicant must obtain approval from the University Radiation Safety Committee through the Health Physics Group and with the prior approval of his Departmental Representative, for an Authorization Number. The details of the approval procedure appear in Appendix II.

2. There are two types of Authorization Numbers; "Isotope Authorization Numbers", and "Irradiation Authorization Numbers" for irradiations of a target in a reactor or an accelerator. Use H.P. Form #20 for a Radioisotope, H.P. Form #30 for an Irradiation. A person applying for the first time for an "Authorization Number" of either type would do well to contact the "Health Physics Officer" after an initial consultation with his Departmental Representative.

3. Either type of "Authorization Number" is normally valid for two years. The activity specified in Curie units on the approved application indicates the maximum possession limit.

4. Responsible Investigators holding an "Irradiation Authorization Number" may make a series or multiple irradiations of the type approved but shall inform the Health Physics Group before making each irradiation.

B. Limited Possession Number

1. Persons wishing to possess and use amounts considered to be generally licensed(exempt) quantities, and not able to qualify as a Responsible Investigator shall apply for a "Limited Possession Number" on H.P. Form #55. A "Limited Possession Number" authorizes possession of up to 10 times the generally licensed quantity of a single radioisotope or the equivalent prorated quantities of several radioisotopes

as determined by the calculation in footnote 2 to Appendix C. "Limited Possession Number" are normally valid for one year.

2. The "Limited Possession Number" is distinguished from an "Authorization Number" by the following:

a. the lower possession limit and shorter period of validity as defined above.

b. in considering the qualifications of the applicant less emphasis is placed on previous radioisotope experience, therefore, the scope of activities permitted is limited with respect to those permitted under an "Authorization Number".

3. "Limited Possession Numbers" may be assigned by the "Health Physics Officer" after approval by the applicant's Departmental Representative to the Radiation Safety Committee. Either the Departmental Representative or the "Health Physics Officer" may deny any such request or require that the proposed activities be referred to the entire Committee for approval as an "Authorization Number" if the individual qualifies as a Responsible Investigator. If the applicant does not qualify he must arrange to work under the supervision of a "Responsible Investigator".

C. The renewal of "Authorization" or "Limited Possession Numbers" may be easily done by sending a letter requesting renewal to the Health Physics Group thirty days prior to its expiration. Requests for increases or substantial changes in the proposed uses will be treated as new applications.

D. Purchase orders for radioisotopes must bear the appropriate "Authorization" or "Limited Possession Number" and be approved by the Health Physics Group. They may be sent either to the Purchasing Department or to the Health Physics Group. The second alternative saves time.

E. Loans and transferrals of radioisotopes are permitted only to per-

sons holding the appropriate "Authorization" or "Limited Possession Numbers". The Health Physics Group must be notified of transferrals. Off campus transferrals must have prior approval of both the Princeton Health Physics Group and the receiving organization.

V. THE RESPONSIBLE INVESTIGATOR'S RESPONSIBILITIES

A. Before the commencement of work with radioisotopes, a "Responsible Investigator" must satisfy the Radiation Safety Committee that he is qualified to handle them safely. This is accomplished by the Authorization Number application approval procedure detailed in Appendix H.

B. A change of responsibility for the conduct of an investigation shall be reported to the "Health Physics Officer". The new "Responsible Investigator" must have on file with the Health Physics Group a"Statement of Training"and possess the appropriate "Authorization Numbers".

C. During the absence of the "Responsible Investigator" radioisotopes shall not be used unless another "Responsible Investigator" assumes responsibility.

D. The acceptance of an "Authorization"or "Limited Possession Number" obligates the "Responsible Investigator" to insure radiation safety to himself, to others and to University property as well as to maintain a certain number of records. *The insurance of safety comes from appropriate attitudes and training.* He also assumes responsibility for the actions of those using radioisotopes under his supervision.

E. Record keeping includes those items needed for orderly management of the laboratory such as receipt, use, transferral and disposal log book and those for radiation protection such as survey log, exposure log, etc.

F. The "Responsible Investigator" shall acquire appropriate survey instruments to insure safety.

G. The "Responsible Investigator" shall also become acquainted and comply with the sections that follow.

VI. PERSONNEL MONITORING

A. It is required that any person who receives or is likely to receive 25% (5% for minors) of the permissible external exposures (see Appendix D) or enters a "High Radiation Area" must wear a film badge. Any question of interpretation of this section shall be referred to the "Health Physics Officer". It shall be the responsibility of the "Responsible Investigator" to see that the personnel required to wear personal monitoring equipment (e.g., film badges, ionization chambers, etc.) actually do so. The "Health Physics Officer" will provide assistance in this matter.

B. The centralized film badge service shall be utilized by laboratories using film badges.

1. U.S.R.C. members or their designated representatives receive periodically a film badge account listing which indicates the current status of their film badge account. This report is accompanied by H.P. Form 8 which explains, in detail, the administrative procedure to be followed in initiating or cancelling film badge service. Any required changes in the film badge account, due to new personnel, terminations etc. should be reported promptly to the "Health Physics Officer".

2. A record of the accumulated dose of all employees with regular film badge service is maintained by the Health Physics Office. In order to determine the accumulated exposure, the radiation exposure history of the individual prior to his employment by Princeton University shall be obtained through H.P. Form #1 and Form #2, Pre-Employment History And Statement of Agreement, A Letter - Request for Previous Exposure Record.

3. Radiation workers who are occupationally exposed to ionizing radiation in a situation outside the control of the University (e.g.,

at other Universities, National Laboratories etc.) should request that all exposure information be sent to the Princeton University Health Physics Office.

4. A cumulative summary of a radiation worker's occupational exposure to penetrating radiation may be obtained by him at any time upon request. He may also receive, upon request, such a summary at the termination of his employment. Such request will be honored within 30 days of receipt of the final data from the film service company. Such requests must include the dates of employment, social security number, and the department where employed.

5. If the Maximum Permissible Doses are changed in the Federal Register or in the New Jersey Radiation Protection Code, Appendix D will be reissued showing the new limits.

6. Each Department will receive a copy of the monthly exposure report.

C. Exposures Exceeding the Maximum Permissible Dose.

1. If it appears possible that an individual has received an exposure greater than the permissible limits indicated in Appendix D the "Health Physics Officer" shall be notified immediately. The "Health Physics Officer" shall take steps to determine the actual exposure, investigate and document the circumstances and make suggestions for corrective action if necessary.

2. Individuals who are believed to have been over-exposed shall be suspended from further work with sources of ionizating radiation pending the outcome of the "Health Physics Officer's" investigation.

D. Exposure of Minors

Occupational exposure to persons under the age of 18 or women known to

be pregnant is permitted only if their exposures are limited to 10% or less than those specified in Appendix D, paragraph A. For this reason it is recommended that minors not be employed as full time radiation workers and that the work assignments of women be reviewed when the occurrence of a pregnancy is established, to insure compliance with the above.

E. Exposure of Visitors

1. The host (person visited) is responsible to insure that his visitor complies with all safety regulations and wears film badges where and when required. Because of reporting requirements it is important that both sides of the visitor film badge card be completed and that the badge and card be returned promptly to the Health Physics Office for processing and interpretation.

2. There are very few circumstances in which any real contribution to the scientific community can result from the visit of a woman known to be pregnant or children to a restricted area. For this reason such visits shall be discouraged and not permitted without benefit of careful consideration. Prolonged or frequent visits by children to restricted areas are prohibited.

VII. INTERNAL EXPOSURE CONTROL AND BIOASSAYS

A. Bioassays analyses may be required of any person or persons who:

1. have been exposed to air or water concentrations of radioactive material equal to or in excess of 25% of those specified in Table I of Appendix B,

2. have been involved in a spill, an incident, or other activity during which significant amounts of radioactive material may have been taken into the body either by inhalation, ingestion, or by absorption through the skin or a wound.

B. Routine bioassays are required at the following intervals for per-

sonnel handling tritium in forms which present an inhalation possibilty (e.q., other than sealed sources, targets, foils etc.).

Amount of Tritium	Bioassay Interval
100 mc to 8 curie	weekly
8 curies or more	daily
an incident or release involving 100 mc or more	immediately and daily for a period of time depending on the initial results.

C. Arrangements shall be made with the "Health Physics Officer" to obtain bioassays. Any planned experimental procedures which might result in the need for a bioassay program shall be referred to the "Health Physics Officer" at the earliest possible date.

VIII. POSTING, LABELING AND TAGGING REQUIREMENTS

A. Each laboratory or group of laboratories using "Sources of Radiation" must have certain materials and forms posted or displayed and other documents available for ready reference.

B. Areas and equipment in which "Sources of Radiation" are present and/or used must be posted, labeled or tagged in accordance with closely defined specifications.

C. All requirements for posting, labeling and tagging are described in detail in Appendix I.

IX. LABORATORY PROCEDURES

A. A Radioisotope Log Book shall be maintained in each laboratory containing an inventory of radioisotopes, noting element and mass number, date received, amount received, dates of withdrawal for use, amount

withdrawn, date of disposal of waste, manner of disposal and estimated amount of waste. In short, a continual record must be maintained from receipt to disposal or decay.

There are two radiochemical laboratories routinely investigating and handling targets irradiated in accelerators based at Princeton; an 18 Mev proton synchrocyclotron and a 3 Gev proton synchrotron. The inventorying of target activity levels is difficult because of the broad spectrum of activities and activity levels met in these targets. However, it is possible to estimate activity levels or to express the data in mr/hour at some specified distance. It is necessary that a record be kept indicating the disposition of these materials. Transfer of radioisotopes produced in these accelerators to other groups outside these radiochemical laboratories shall be made in the normal manner prescribed in this manual.

B. The laboratory personnel shall routinely conduct their own surveys in addition to surveys made by the Health Physics Group. The purpose of these surveys is two-fold: to gauge the exposure of workers to radiation in carrying through a particular procedure and to spot-check for possible areas of contamination. After any procedure in which the possibility of contamination exists spot checks must be made.

C. A Survey Log Book shall be maintained in each laboratory and all surveys shall be entered therein. If a survey is deemed necessary, its findings must be recorded even if negative. The entries need not be elaborate. A simple statement of findings and date shall suffice. The reports of laboratory surveys made by the Health Physics Group shall be filed in this same log book.

D. At present, two monthly reports must be filed by the "Responsible Investigator": a listing of radioisotopes at hand and a listing of radioisotope disposals into the sewage system. Convenient forms for these reports are available from the Health Physics Group.

E. A person performing radiochemical operations using open or sealed

sources, or opening packages containing or suspected of containing radioisotopes, must have immediately available a suitable and operative radiation detector. This detector must be able to indicate either exposure dose or activity considering the nature and strength of the source.

F. Radioisotopes should be stored in unshatterable containers. However, if the nature of the radioisotope compound is such that it may be desirable or necessary to store it in a shatterable vessel, this vessel must be enclosed in a sealable spill-proof container.

G. No radioactive material is to be moved in such a manner that it is possible for the material to escape from the container. Liquids, gases and dispersable solids must be transported in suitable vessels with the outer containing wall of non-shatterable material. Liquids and gases should be transported in double-walled containers. Surface contamination on articles for decontamination or waste disposal can usually be contained by wrappings of polyethylene and sealed with masking tape. The outside surface contamination of packages which are to be transported must be below 10 alpha dpm and 100 beta dpm on a 100 square centimeter smear.

H. No smoking or eating is to be done in radioisotope laboratories (this includes gum, candy and beverages). Refrigerators used to store radioactive materials are not to be used for food storage at any time.

I. Before leaving a laboratory where radiochemical operations are carried out, the hands must be washed and checked with a survey meter. Laboratory coats and shoes must also be surveyed and if found contaminated, they must remain in the radioisotope laboratory until decontamination has been completed or they must be disposed as if they were radioactive waste.

J. Experiments involving the use of radioisotopes in quantities greater than 10 times but less than 1000 times maximum body burden, shall be carried out in filtered and coated fume hoods with face air velocity of 100 feet per minute or greater. Experiments involving quantities greater than 1000 body

burdens shall be carried out in a closed system. The body burden shall be those specified in the National Bureau of Standards, Handbook 69, 1959 as amended.

K. Protective gloves should be worn in all cases where active material or solutions of active material may come in contact with the hands. They must be worn when handling 10 times the amounts shown in Column A of Appendix C.

L. Persons who work in or frequent Airborne Radioactivity Areas may be required to obtain routine bioassays. No person should enter a room or area where it is known or suspected that the tolerance for airborne radioactivity is exceeded without wearing a suitable respirator or air mask. No operation is to be performed which might cause radioactivity to become airborne in excess of permissible levels unless every person present is protected by a suitable respirator or air mask. Health Physics approval must be obtained before carrying out any such operation. A routine air sampling program may be required in such areas.

M. Pipetting of radioactive solutions by mouth is prohibited.

N. All work with volatile or dust-forming radioactive materials shall be confined to hoods or glove boxes, preferably the latter.

O. No extensive radiochemical work shall be performed with hazardous materials until the procedure has been tested by means of a "dummy" run. "Extensive radiochemical work" shall signify one or more chemical reactions involving radioactive substances, and/or the transfer of radioactive substances from one vessel to another four or more times, but it shall not include such physical processes as source preparation by evaporation.

P. No radiochemical operation shall be performed directly on unsuitable laboratory table tops. All such work must be done on smooth surface (stainless steel or enameled trays) or on an absorbent paper.

Q. Radioisotopes received in shipment must be opened in a properly equipped laboratory and only by the authorized user or under his immediate supervision.

R. In cases where exceptional hazards may exist, special safety equipment and precautions may be required as determined by consultation with the "Health Physics Officer". These may include specialized shielding, clothing and monitoring apparatus.

S. Unauthorized entry into "Restricted Areas" must be forbidden. Authorized visitors should be supervised by a responsible member of the laboratory. Radioisotopes shall not be left unattended in places where unauthorized persons may handle them or take them without realizing that they are radioactive. Doors of unoccupied laboratories shall be locked as well do windows where ingress by this means is possible.

T. Theft or loss of radioactive material shall be reported immediately by telephone to the "Health Physics Officer".

U. Instruction of new radiation workers in the techniques and hazards of their work is required. The "Responsible Investigator" in whose laboratory the work is carried out shall provide the necessary instruction. "The Health Physics Officer" may provide assistance in such instruction upon request.

V. The disposition of unused radioisotopes remaining at the completion of an investigation shall be discussed with the"Health Physics Officer."

W. The State of New Jersey requires that all radioactive materials be registered. This is accomplished by the Monthly Radioisotope Inventory (H. P. Form #5). The Health Physics Group collects and collates the input data from all "Responsible Investigators" and files the required report. The report shall be in the Health Physics Office by the tenth of the month and will indicate all radioactive materials <u>on hand</u>, including

wastes and stores, as of the first working day of the month.

X. SEALED SOURCES AND LEAK TESTS

A. Each "Sealed Source", as defined in Section II, obtained from another person shall be tested for contamination and/or leakage:

1. prior to use, in the absence of a certificate indicating that a test has been made within the last six months

2. at intervals not exceeding six (6) months except that sources designed for the purpose of emitting alpha particles shall be tested at intervals not exceeding three (3) months.

B. "Sealed Sources" are exempt from the required periodic leak test (but not the original test) if:

1. they contain only tritium

2. they contain less than the activity listed in Column B Appendix C.

3. if the activity consists entirely of a gas.

C. If the required tests indicate the presence of 0.005 μc or more of transferable contamination, the source shall immediately be withdrawn from service and be either decontaminated and/or repaired and retested, or disposed of as radioactive waste.

D. All "Sealed Sources" manufactured by University personnel must be tested in accordance with the above prior to use and at the intervals specified above unless exempted from the periodic test as per Paragraph B.

E. In the event a source is determined to be contaminated and/or leaking, a report must be filed within five (5) days with the A.E.C. and the state of New Jersey indicating the test results, the equipment

used and the corrective action taken.

F. Sources obtained as sealed sources shall not be opened.

G. The Health Physics Group shall provide the required leak tests for all University "Sealed Sources", maintain the required records, suggest corrective action where indicated and file the necessary reports. To implement this service all "Responsible Investigators" shall:

1. inform the "Health Physics Officer" in writing of the receipt or manufacture of a new source, or the disposal of an old one,

2. recall sources on loan to a central point, and generally assist in locating all sources when the scheduled tests are to be performed.

XI. RADIOACTIVE WASTE DISPOSAL

There are strict requirements placed on the manner and methods used for the disposal of radioactive wastes which apply to the University as a whole, as the licensee. In order to comply with these requirements the following procedures are established and shall be followed.

A. The centralized radioactive waste disposal service shall be used by all persons and groups with such disposal requirements. Collection is made on a bi-weekly basis.

1. All experimental residues and first rinses shall be placed in waste cans.

2. Liquid wastes shall be placed in liquid waste cans (containing an absorbent material) or in dry waste cans if first contained in an unshatterable vessel.

3. The amount of radioactive materials placed in waste cans must be recorded on the tag fastened to the can. A reasonable estimate of the activity is sufficient.

4. Waste cans shall not be used for non radioactive wastes.

5. Waste cans shall be placed in a safe location to prevent their damage. If the contents give rise to a significant external gamma field, the can shall be adequately shielded or placed in an area not frequented by personnel.

6. Gamma and neutron emitters placed in waste cans shall be shielded so that the total radiation dose rate at one meter from the side of the can is less than 2 mrem/hr and the contact dose rate is less than 20 mrem/hr.

B. It is forbidden to use the University sewage system as a primary means of radioisotope waste disposal. This follows because of the very low limits established by Federal and State Laws and because the extreme complexity of the University sewage systems precludes the establishment of a monitoring system. However, some disposal to the sewer is permitted subject to the following conditions:

1. Daily disposals by individuals be limited to less than 1/10 of the amounts specified in Column A of Appendix C, provided the "Responsible Investigator" provides sufficient local dilution to insure compliance with the daily concentration limits set forth in Table I Appendix B. A record of such disposals shall be entered in the laboratory "Radioisotope Log Book".

2. In order to insure compliance with the monthly average concentration limit and the yearly total limit (1 Curie) the Health Physics Office will compute, and record the various concentrations and totals each month. The input data, including negative reports, shall be provided by each "Responsible Investigator" on Health Physics Form #11. The report shall include a record of all disposals to the sanitary sewer for the calendar month and is due on the 10th of the following month.

3. No radioactive material may be placed in the sanitary sewer unless it is readily soluble or dispersable in water.

C. There are no facilities at the University for incineration or burial of radioactive wastes.

XII. PROCUREMENT OF RADIATION-PRODUCING EQUIPMENT AND MACHINES

A. A Department or a "Responsible Investigator" planning to install or re-activate radiation-producing equipment (such as x-ray machines, irradiation facilities, etc.) acquired by purchase or otherwise, shall obtain approval of his plans by the Radiation Safety Committee. The responsibility for having the proposal presented to the Radiation Safety Committee rests with the "Director of the Laboratory". Early consultation with the "Health Physics Officer" will facilitate the planning of the installation and the preparation of the proposal to the Committee.

Note: The reader is reminded that electronic gear which operates at high voltages is sometimes capable of producing ionizing radiation even though such production is not its primary purpose.

B. Every radiation producing machine must be registered with the State of New Jersey within 15 days of its initial installation. This applies to any machine which results in the existence of a radiation field equal to or greater than 5 mrem/hr at 5 cm from any accessible point - even if the radiation is incidental to its purpose. Assistance in complying with this requirement shall be obtained from the "Health Physics Officer".

C. All such equipment must be labelled on the control panel so as to remind the operator of the fact that when in operation, ionizing radiation is produced.

XIII. TRANSPORTATION AND SHIPMENT OF RADIOACTIVE MATERIALS

A. Radioisotopes transported to destinations outside the University, or transferred between campuses, shall be packaged and transported in accordance with all pertinent regulations. See Appendix F for some details.

B. A University employee preparing a radioactive substance for transportation by an individual or agency not associated with the University shall have the responsibility to insure full compliance with pertinent

regulations with respect to packaging, marking and labeling of the container.

C. A University employee who is to transport a package of radioactive material received from an individual or agency not associated with the University shall have the responsibility to acquaint himself with regulations relating to transportation of the material in question and to satisfy himself that the conditions of packaging and transport comply with those regulations.

D. In the case of transportation by private automobile, the radioactive material shall be in the charge of an individual occupationally engaged in work with radioisotopes. The package shall be placed in the trunk of the automobile, if possible; otherwise, it shall be placed at least two feet from the nearest occupant. It shall be suitably marked with the name and university address of the owner, a notice that the contents might be dangerous if removed, and that the owner and/or the University Health Physics Office should be notified if the package is found. If it is necessary to leave radioactive materials in an unattended car the package shall be locked in the car, preferably in the trunk.

An individual who transports radioisotopes in such quantity that the gamma ray dose during a trip is more than half the limit specified in Appendix F, paragraph B-3, shall wear a film badge during transportation.

XIV. MEDICAL CONSIDERATIONS

A. Slit-Lamp Eye Examinations

1. All personnel potentially exposed to fast neutrons or to high radiation fields, the geometery of which are highly localized (diffraction X-ray units, etc.), and to the extent that they require a film badge, shall obtain slit-lamp eye examinations for incipient cataracts at the following times:

a. at hiring (initial)

b. at intervals of approximately two years

c. at termination

B. The "Health Physics Officer" shall establish the necessary procedures to insure the scheduling of the eye examinations, and assist the Medical Department in conducting them.

C. For the purposes of this section initiation and termination of employment shall be deemed to occur at the beginning and end, respectively, of the employee's work with a "Source of Radiation". Thus, a Princeton employee who has been working in a capacity not involving radiation shall, if he undertakes work involving radiation, be considered a new employee for purposes of radiation safety. Similarly, an individual who ceases to work with a source of radiation shall be considered terminated for purposes of radiation safety, although the individual in question may not have severed his association with the University.

The provisions of this Section with respect to termination do not apply to radiation workers who may be on vacation, absent for reasons of illness, or "between experiments".

D. Changes in personnel shall be reported to the "Health Physics Officer". Notice of anticipated terminations should be given as early as possible to facilitate arranging for the slit-lamp eye examinations and cancellation of film service.

XV. EMERGENCY PROCEDURES

A. In the event of the escape of a radioactive substance from its normal confines (spill, evaporation, vaporization, combustion, escape of a gas, liquid, solid, etc.) in an amount which is known to exceed

or may exceed ten times the quantities listed in Column A, Appendix C, the "Health Physics Officer" shall be notified promptly. Dial 3131 and provide the responding officer with the information he requests: Pending arrival of the "Health Physics Officer" the following steps should be taken:

1. Where Airborne Contamination (from evaporation, vaporization, explosion, combustion, formation of a smoke, dust, spray, escape of a gas, etc.) may have occurred:

a. Evacuate the laboratory immediately,

b. Shut all doors to the laboratory. Shut down the air conditioning,

c. Post a guard to insure that no one re-enters the laboratory and to keep the general area clear of spectators,

d. Assemble all persons who were in the laboratory at the time of accident. The place of assembly should be near the contaminated area, in order to reduce the spread of contamination about the building.

e. Monitor assembled personnel to determine whether contamination of the skin or clothing exists. If such contamination is found, proceed as follows:

(1) Remove all contaminated clothing,

(2) Flush contaminated cuts with running water,

(3) Wash contaminated areas of skin with soap and water,

f. Do not linger in an area of a dry spill without respiratory protection.

2. Where Ingestion of a radioisotope may have occurred:

a. Induce vomiting by placing a finger well back in the throat.

b. Have the victim drink a pint of water and induce vomiting again.

3. Where there is a spill of a substance that will not readily become airbone (such as a solid not so finely divided that it may be carried about as dust, or a liquid of relatively low volatility, such as an aqueous solution provided spraying did not occur):

a. Block off the area, using a rope barrier or items of furniture, to insure that others will not walk through the area.

b. Monitor the skin and clothing of persons near the site of the spill. If contamination is found, proceed as in 1-e.

4. The escape of a radionuclide in an amount exceeding by less than a factor of ten the quantity indicated in Column A, Appendix C, need not be treated as an accident for the purposes of this Section. However, the laboratory shall be decontaminated, and a record shall be made of the incident.

B. Emergencies occasionally occur during other than normal working hours. In these cases it becomes imperative that persons having a knowledge of the specific laboratory and its hazards be available for consultation. This is important both for safety considerations and from the point of view of coping with the emergency effectively. For these reasons each laboratory in which "Sources of Radiation" exist shall post the following information on or near the entrance to the laboratory.

1. The name and phone numbers of the "Responsible Investigator" and several assistants, when possible.

2. An indication of any special or unique hazards (radioisotopes,

electrical, highly toxic compounds,etc.) and/or special instructions for emergency personnel.

3. The names and phone numbers of "Health Physics Officers."

C. Health Physics Form #31 is available and may be used to provide this information.

XVI. FINANCIAL CONSIDERATIONS

A. The normal operating costs incurred by the Health Physics Group are distributed at quarterly intervals among those persons and groups using sources of radiation according to the following scheme.

1. Formula for the Calculation of a Group's share. The fraction of the costs to be borne by any group is calculated quarterly, using the following formula:

$$\text{Fraction of costs for the } j\text{th Group} = \frac{N_j R_j}{\sum_i N_i R_i}$$

where, N_i = number of people in the ith group during in question

R_i = severity (=risk) factor associated with the activities of the ith group during the quarter in question

2. Generation of N_i

N_i is estimated only twice per year (it takes a lot of time in some groups; therefore, it is a nuisance to do) although it is needed four times per year. The determination of N_i (known as "nose counting") is made around the beginning of January and the beginning of June. The January nose count is used for the fourth quarter of the previous

year and the first quarter of that year. The June nose count is used for the second and third quarters of that year. The rule to decide whom to count and whom to ignore is given by "any person belonging to a group and spending on the average four (4) hours or more per week in a restricted area or using radioisotopes shall be counted for the purpose of determining the group's share in the distribution of Health Physics Group's costs." Note that this rule makes no exceptions with respect to faculty, graduate students or Departmental Representatives. The nose counting is left to the integrity and honor of the "Responsible Investigator" and Departmental Representative.

3. The values of the Ri's are taken from the following table:

Isotopes	R
Less than 10 sources, each source less than 10^3 MBB*	1
More than 10 sources, each source less than 10^3 MBB*	2
Less than 10 sources, any one source more than 10^3 MBB*	2
More than 10 sources, any one source more than 10^3 MBB*	4
Radiation Producing Machines	
X-ray machines	1
Low power heavy ion machines, P_{beam} . 1w	2
High power heavy ion machines, P_{beam} > 1w	4

*MBB = Maximum Body Burden

4. The fraction of the costs is used twice by the controllers office, once for equipment and materials, once for salaries and benefits. Specific overheads are charged on the salaries and benefits portion, according to the various contractual terms.

B. Persons planning to use "Sources of Radiation" in their research are advised to give consideration to the financial aspects of such an

undertaking. Such consideration should include the costs of monitoring equipment which might be needed (portable GM monitors, air sampling equipment, survey meters, signs, labels etc.) as well as the quarterly assessments arising from Health Physics Group costs. Appropriate funds should be included in the proposed budget.

XVII. MISCELLANEOUS

A. Departments planning new construction or renovations which include facilities to be used for radiation work are advised to obtain the services of the "Health Physics Officers" and/or members of the University Radiation Safety Committee in designing these facilities.

B. Departments in which "Sources of Radiation" are used shall insure that University maintenance personnel are informed of the fact and that they are advised to consult with the "Responsible Investigators" and/or "Health Physics Officers" before commencing work. Maintenance work in or around restricted areas such as, filter changes on fume hoods used in radiation work, plumbing repairs on sinks, janitorial services in cleaning up spills,etc. should be done only after such consultation with and in some cases,under the direct supervision of Health Physics personnel.

C. Since any significant change in the radiation hazards existing in a Department will result in a change in the insurance premium and/or the coverage requirements, department officials should insure that the specific information is communicated to the "Health Physics Officer". Upon request the "Health Physics Officer" will provide assistance in completing insurance forms and reports.

Appendix A

THE RADIATION SAFETY COMMITTEE (AS OF FEBRUARY 1966)

Dr. M. Awschalom, Accelerator, Secretary of the Committee
Prof. R.C. Axtmann, Chemical Engineering
Prof. H.D. Holland, Geology
Mr. L.R. Hyde, Biology
Dr. R.V. Wolfenden, Chemistry
Dr. W.B. Mather, Health Services
Prof. T.D. Thomas, Nuclear Chemistry
Prof. R.E. Pollock, Physics
Prof. B.S. H. Royce, Aerospace and Mechanical Sciences
Dr. M.A. Rathman, Plasma Physics Laboratory
Dr. L. Turner, Office of Research Administration, Chairman of Committee

HEALTH PHYSICS OFFICERS

Name	Phone
Dr. Miguel Awschalom, Head Health Physics Group Princeton-Pennsylvania Accelerator	Office: 452-5378 Home : [redacted] EX6
Mr. Jack C. Faust University Health Physicist James Forrestal Campus	Office: 452-5294 Home : [redacted] EX6
Mr. Walter Schimmerling University Health Physicist James Forrestal Campus	Office: 452-5294 Home : [redacted] EX6

HEALTH PHYSICS OFFICE

Room 101 Chemical Science Building
James Forrestal Campus

Telephone: Ext: 5294 or 5295

APPENDIX B

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND

[See notes at end of appendix]

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

See footnotes at end of table.

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
Cesium (55)	Cs 131	S	1×10^{-6}	7×10^{-6}	4×10^{-7}	2×10^{-6}
		I	3×10^{-6}	3×10^{-5}	1×10^{-7}	9×10^{-6}
	Cs 134m	S	4×10^{-6}	2×10^{-4}	1×10^{-6}	6×10^{-6}
		I	6×10^{-6}	3×10^{-4}	2×10^{-7}	1×10^{-5}
	Cs 134	S	4×10^{-8}	3×10^{-4}	1×10^{-8}	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^{-8}
		I	2×10^{-7}	2×10^{-3}	6×10^{-9}	6×10^{-8}
	Cs 137	S	6×10^{-8}	4×10^{-4}	2×10^{-9}	2×10^{-8}
		I	1×10^{-8}	1×10^{-3}	5×10^{-10}	4×10^{-8}
Chlorine (17)	Cl 36	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-8}
		I	2×10^{-6}	2×10^{-3}	8×10^{-10}	6×10^{-8}
	Cl 38	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-7}
		I	2×10^{-6}	1×10^{-2}	7×10^{-8}	4×10^{-7}
Chromium (24)	Cr 51	S	1×10^{-3}	5×10^{-3}	4×10^{-7}	2×10^{-4}
		I	2×10^{-6}	5×10^{-3}	8×10^{-8}	2×10^{-4}
Cobalt (27)	Co 57	S	3×10^{-6}	2×10^{-3}	1×10^{-7}	5×10^{-4}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-4}
	Co 58m	S	2×10^{-5}	8×10^{-3}	6×10^{-7}	3×10^{-4}
		I	9×10^{-6}	6×10^{-3}	3×10^{-7}	2×10^{-4}
	Co 58	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	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^{-7}
		I	2×10^{-10}	7×10^{-4}	6×10^{-12}	3×10^{-7}
	Cm 243	S	6×10^{-12}	1×10^{-3}	2×10^{-12}	5×10^{-4}
		I	1×10^{-10}	7×10^{-4}	3×10^{-12}	2×10^{-7}
	Cm 244α	S	9×10^{-12}	2×10^{-3}	3×10^{-12}	7×10^{-4}
		I	1×10^{-10}	8×10^{-3}	3×10^{-12}	3×10^{-6}
	Cm 245	S	5×10^{-12}	1×10^{-3}	2×10^{-12}	4×10^{-4}
		I	1×10^{-10}	8×10^{-3}	4×10^{-12}	3×10^{-6}
	Cm 246	S	5×10^{-12}	1×10^{-3}	2×10^{-12}	4×10^{-4}
		I	1×10^{-10}	8×10^{-3}	4×10^{-12}	3×10^{-6}
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^{-4}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-4}
Erbium (68)	Er 169	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-4}
		I	4×10^{-7}	3×10^{-3}	1×10^{-8}	9×10^{-4}
	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 (T/2=9.2 hrs)	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-8}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-8}
	Eu 152 (T/2=13 yrs)	S	1×10^{-8}	2×10^{-3}	4×10^{-10}	8×10^{-8}
		I	2×10^{-8}	2×10^{-3}	6×10^{-10}	8×10^{-8}
	Eu 154	S	4×10^{-8}	6×10^{-4}	1×10^{-10}	2×10^{-8}
		I	7×10^{-8}	6×10^{-4}	2×10^{-10}	2×10^{-8}
	Eu 155	S	9×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-7}
		I	7×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-7}
Fluorine (9)	F 18	S	5×10^{-6}	2×10^{-2}	2×10^{-7}	8×10^{-7}
		I	3×10^{-6}	1×10^{-2}	9×10^{-8}	5×10^{-4}
Gadolinium (64)	Gd 153	S	2×10^{-7}	6×10^{-3}	8×10^{-9}	2×10^{-4}
		I	9×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}
	Gd 159	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Gallium (31)	Ga 72	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Germanium (32)	Ge 71	S	1×10^{-3}	5×10^{-3}	4×10^{-7}	2×10^{-3}
		I	6×10^{-6}	5×10^{-3}	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}

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
Gold (79)	Au 199	S	1×10⁻⁶	5×10⁻⁵	4×10⁻⁶	2×10⁻⁴
		I	8×10⁻⁷	4×10⁻⁵	3×10⁻⁶	2×10⁻⁴
Hafnium (72)	Hf 181	S	4×10⁻⁶	2×10⁻⁵	1×10⁻⁵	7×10⁻⁵
		I	7×10⁻⁶	2×10⁻⁵	3×10⁻⁶	7×10⁻⁶
Holmium (67)	Ho 166	S	2×10⁻⁷	9×10⁻⁶	7×10⁻⁶	3×10⁻⁵
		I	2×10⁻⁷	9×10⁻⁶	6×10⁻⁶	3×10⁻⁵
Hydrogen (1)	H3	Sub	5×10⁻⁶	1×10⁻¹	2×10⁻⁷	3×10⁻³
			2×10⁻³	----------	4×10⁻⁵	----------
Indium (49)	In 113m	S	8×10⁻⁶	4×10⁻⁵	3×10⁻⁷	1×10⁻³
		I	7×10⁻⁶	4×10⁻⁵	2×10⁻⁷	1×10⁻³
	In 114m	S	1×10⁻⁷	5×10⁻⁶	4×10⁻⁹	2×10⁻⁵
		I	2×10⁻⁶	5×10⁻⁶	7×10⁻¹⁰	2×10⁻⁵
	In 115m	S	2×10⁻⁶	1×10⁻⁵	8×10⁻⁹	4×10⁻⁵
		I	2×10⁻⁶	1×10⁻⁵	6×10⁻⁹	4×10⁻⁵
	In 115	S	2×10⁻⁷	3×10⁻⁵	9×10⁻⁹	9×10⁻⁵
		I	3×10⁻⁶	3×10⁻⁵	1×10⁻⁹	9×10⁻⁵
Iodine (53)	I 125	S	8×10⁻⁹	5×10⁻⁸	[illegible]	[illegible]
		I	3×10⁻⁷	3×10⁻⁸	[illegible]	9×10⁻⁸
	I 129	S	2×10⁻⁹	1×10⁻⁸	[illegible]	[illegible]
		I	7×10⁻⁹	6×10⁻⁸	2×10⁻⁹	2×10⁻⁷
	I 131	S	9×10⁻⁹	6×10⁻⁸	1×10⁻¹⁰	[illegible]
		I	3×10⁻⁷	2×10⁻⁸	1×10⁻⁹	6×10⁻⁸
	I 132	S	2×10⁻⁷	2×10⁻⁸	[illegible]	[illegible]
		I	9×10⁻⁷	5×10⁻⁸	[illegible]	2×10⁻⁷
	I 133	S	3×10⁻⁹	2×10⁻⁷	[illegible]	[illegible]
		I	2×10⁻⁷	1×10⁻⁸	7×10⁻⁹	4×10⁻⁷
	I 134	S	5×10⁻⁷	4×10⁻⁸	[illegible]	[illegible]
		I	3×10⁻⁶	2×10⁻⁸	1×10⁻⁷	6×10⁻⁷
	I 135	S	1×10⁻⁷	7×10⁻⁷	[illegible]	[illegible]
		I	4×10⁻⁷	2×10⁻⁸	1×10⁻⁸	7×10⁻⁸
Iridium (77)	Ir 190	S	1×10⁻⁶	6×10⁻⁵	4×10⁻⁶	2×10⁻⁴
		I	4×10⁻⁷	5×10⁻⁵	1×10⁻⁶	2×10⁻⁴
	Ir 192	S	1×10⁻⁷	1×10⁻⁵	4×10⁻⁹	4×10⁻⁵
		I	3×10⁻⁶	1×10⁻⁵	9×10⁻¹⁰	4×10⁻⁵
	Ir 194	S	2×10⁻⁷	1×10⁻⁵	8×10⁻⁹	3×10⁻⁵
		I	2×10⁻⁷	9×10⁻⁶	5×10⁻⁹	3×10⁻⁵
Iron (26)	Fe 55	S	9×10⁻⁷	2×10⁻⁵	3×10⁻⁶	8×10⁻⁵
		I	1×10⁻⁶	7×10⁻⁵	3×10⁻⁶	2×10⁻⁵
	Fe 59	S	1×10⁻⁷	2×10⁻⁵	5×10⁻⁹	6×10⁻⁵
		I	5×10⁻⁹	2×10⁻⁵	2×10⁻⁹	5×10⁻⁵
Krypton [2] (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	----------
Lanthanum (57)	La 140	S	2×10⁻⁷	7×10⁻⁶	5×10⁻⁹	2×10⁻⁵
		I	1×10⁻⁷	7×10⁻⁶	4×10⁻⁹	2×10⁻⁵
Lead (82)	Pb 203	S	3×10⁻⁶	1×10⁻⁵	9×10⁻⁹	4×10⁻⁵
		I	2×10⁻⁶	1×10⁻⁵	6×10⁻⁹	4×10⁻⁵
	Pb 210	S	1×10⁻¹⁰	4×10⁻⁹	4×10⁻¹²	1×10⁻⁷
		I	2×10⁻¹⁰	5×10⁻⁹	8×10⁻¹²	2×10⁻⁷
	Pb 212	S	2×10⁻⁶	6×10⁻⁶	6×10⁻¹⁰	2×10⁻⁵
		I	2×10⁻⁶	5×10⁻⁶	7×10⁻¹⁰	2×10⁻⁵
Lutetium (71)	Lu 177	S	6×10⁻⁷	3×10⁻⁶	2×10⁻⁸	1×10⁻⁴
		I	5×10⁻⁷	3×10⁻⁶	2×10⁻⁸	1×10⁻⁴
Manganese (25)	Mn 52	S	2×10⁻⁷	1×10⁻⁵	7×10⁻⁹	3×10⁻⁵
		I	1×10⁻⁷	9×10⁻⁶	5×10⁻⁹	3×10⁻⁵
	Mn 54	S	4×10⁻⁷	4×10⁻⁵	1×10⁻⁸	1×10⁻⁴
		I	4×10⁻⁷	3×10⁻⁵	1×10⁻⁸	1×10⁻⁴
	Mn 56	S	8×10⁻⁷	4×10⁻⁵	3×10⁻⁸	1×10⁻⁴
		I	5×10⁻⁷	3×10⁻⁵	2×10⁻⁸	1×10⁻⁴
Mercury (80)	Hg 197m	S	7×10⁻⁷	6×10⁻⁵	3×10⁻⁸	2×10⁻⁴
		I	8×10⁻⁷	5×10⁻⁵	3×10⁻⁸	2×10⁻⁴
	Hg 197	S	1×10⁻⁶	9×10⁻⁵	4×10⁻⁸	3×10⁻⁴
		I	3×10⁻⁶	1×10⁻⁵	9×10⁻⁸	3×10⁻⁴
	Hg 203	S	7×10⁻⁶	5×10⁻⁵	2×10⁻⁸	2×10⁻⁴
		I	1×10⁻⁷	3×10⁻⁵	4×10⁻⁹	1×10⁻⁴
Molybdenum (42)	Mo 99	S	7×10⁻⁷	5×10⁻⁵	3×10⁻⁸	2×10⁻⁴
		I	2×10⁻⁷	1×10⁻⁵	7×10⁻⁹	4×10⁻⁵
Neodymium (60)	Nd 144	S	8×10⁻¹¹	2×10⁻⁸	3×10⁻¹²	7×10⁻⁴
		I	3×10⁻¹⁰	2×10⁻⁸	1×10⁻¹¹	8×10⁻⁴

See footnotes at end of table.

[illegible] 24 FR 1434

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
Neodymium (60)	Nd 147	S	4×10⁻⁷	2×10⁻⁵	1×10⁻⁸	6×10⁻⁵
		I	3×10⁻⁷	2×10⁻⁵	8×10⁻⁹	6×10⁻⁵
	Nd 149	S	2×10⁻⁶	8×10⁻⁵	6×10⁻⁸	3×10⁻⁴
		I	1×10⁻⁶	8×10⁻⁵	5×10⁻⁸	3×10⁻⁴
Neptunium (93)	Np 237	S	4×10⁻¹³	9×10⁻⁸	1×10⁻¹³	3×10⁻⁴
		I	1×10⁻¹⁰	9×10⁻⁴	4×10⁻¹³	3×10⁻⁴
	Np 239	S	8×10⁻⁷	4×10⁻⁵	3×10⁻⁸	1×10⁻⁴
		I	7×10⁻⁷	4×10⁻⁵	2×10⁻⁸	1×10⁻⁴
Nickel (28)	Ni 59	S	5×10⁻⁷	6×10⁻⁵	2×10⁻⁸	2×10⁻⁴
		I	8×10⁻⁷	6×10⁻⁵	3×10⁻⁸	2×10⁻⁴
	Ni 63	S	6×10⁻⁶	8×10⁻⁴	2×10⁻⁸	3×10⁻³
		I	3×10⁻⁷	2×10⁻³	1×10⁻⁸	7×10⁻³
	Ni 65	S	9×10⁻⁷	4×10⁻⁵	3×10⁻⁸	1×10⁻⁴
		I	5×10⁻⁷	3×10⁻⁵	2×10⁻⁸	1×10⁻⁴
Niobium (Columbium) (41)	Nb 93m	S	1×10⁻⁷	1×10⁻³	6×10⁻⁹	4×10⁻³
		I	2×10⁻⁷	1×10⁻³	5×10⁻⁹	4×10⁻³
	Nb 95	S	5×10⁻⁷	3×10⁻³	2×10⁻⁸	1×10⁻³
		I	1×10⁻⁷	3×10⁻³	3×10⁻⁹	1×10⁻³
	Nb 97	S	6×10⁻⁶	3×10⁻³	2×10⁻⁷	9×10⁻³
		I	5×10⁻⁶	3×10⁻³	2×10⁻⁷	9×10⁻³
Osmium (76)	Os 185	S	5×10⁻⁷	2×10⁻⁵	2×10⁻⁸	7×10⁻⁵
		I	5×10⁻⁹	2×10⁻⁵	2×10⁻⁹	7×10⁻⁵
	Os 191m	S	2×10⁻⁵	7×10⁻³	6×10⁻⁷	3×10⁻³
		I	9×10⁻⁶	7×10⁻³	3×10⁻⁷	2×10⁻³
	Os 191	S	1×10⁻⁶	5×10⁻⁵	4×10⁻⁸	2×10⁻⁴
		I	4×10⁻⁷	5×10⁻⁵	1×10⁻⁸	2×10⁻⁴
	Os 193	S	4×10⁻⁷	2×10⁻⁵	1×10⁻⁸	6×10⁻⁵
		I	3×10⁻⁷	2×10⁻⁵	9×10⁻⁹	8×10⁻⁵
Palladium (46)	Pd 103	S	1×10⁻⁶	1×10⁻³	5×10⁻⁸	3×10⁻³
		I	7×10⁻⁷	8×10⁻⁴	3×10⁻⁸	3×10⁻³
	Pd 109	S	6×10⁻⁷	3×10⁻³	2×10⁻⁸	9×10⁻³
		I	4×10⁻⁷	2×10⁻³	1×10⁻⁸	7×10⁻³
Phosphorus (15)	P 32	S	7×10⁻⁸	5×10⁻⁴	2×10⁻⁹	2×10⁻³
		I	8×10⁻⁸	7×10⁻⁴	3×10⁻⁹	2×10⁻³
Platinum (78)	Pt 191	S	8×10⁻⁷	4×10⁻³	3×10⁻⁸	1×10⁻³
		I	6×10⁻⁷	3×10⁻³	2×10⁻⁸	1×10⁻³
	Pt 193m	S	7×10⁻⁶	3×10⁻²	2×10⁻⁷	1×10⁻²
		I	5×10⁻⁶	3×10⁻²	2×10⁻⁷	1×10⁻²
	Pt 197m	S	6×10⁻⁶	3×10⁻³	2×10⁻⁷	1×10⁻³
		I	5×10⁻⁶	3×10⁻²	2×10⁻⁷	9×10⁻³
	Pt 197	S	8×10⁻⁷	4×10⁻³	3×10⁻⁸	1×10⁻³
		I	6×10⁻⁷	3×10⁻³	2×10⁻⁸	1×10⁻³
Plutonium (94)	Pu 238	S	2×10⁻¹³	1×10⁻⁴	7×10⁻¹⁶	5×10⁻⁴
		I	3×10⁻¹¹	8×10⁻⁴	1×10⁻¹³	3×10⁻³
	Pu 239	S	2×10⁻¹³	1×10⁻⁴	6×10⁻¹⁶	5×10⁻⁴
		I	6×10⁻¹¹	8×10⁻⁴	1×10⁻¹³	3×10⁻³
	Pu 240	S	2×10⁻¹³	1×10⁻⁴	6×10⁻¹⁶	5×10⁻⁴
		I	4×10⁻¹¹	8×10⁻⁴	1×10⁻¹³	3×10⁻³
	Pu 241	S	9×10⁻¹¹	7×10⁻³	3×10⁻¹³	2×10⁻³
		I	4×10⁻⁹	4×10⁻³	1×10⁻¹¹	1×10⁻³
	Pu 242	S	2×10⁻¹³	1×10⁻⁴	6×10⁻¹⁶	5×10⁻⁴
		I	4×10⁻¹¹	9×10⁻⁴	1×10⁻¹³	3×10⁻³
Polonium (84)	Po 210	S	5×10⁻¹⁰	2×10⁻³	2×10⁻¹¹	7×10⁻³
		I	2×10⁻⁹	8×10⁻⁴	7×10⁻¹²	3×10⁻³
Potassium (19)	K 42	S	2×10⁻⁶	9×10⁻³	7×10⁻⁸	3×10⁻²
		I	1×10⁻⁷	6×10⁻⁴	4×10⁻⁹	2×10⁻³
Praseodymium (59)	Pr 142	S	2×10⁻⁷	9×10⁻⁴	7×10⁻⁹	3×10⁻³
		I	2×10⁻⁷	9×10⁻⁴	5×10⁻⁹	3×10⁻³
	Pr 143	S	3×10⁻⁷	1×10⁻³	1×10⁻⁸	5×10⁻³
		I	2×10⁻⁷	1×10⁻³	6×10⁻⁹	5×10⁻³
Promethium (61)	Pm 147	S	6×10⁻⁶	6×10⁻³	2×10⁻⁸	2×10⁻²
		I	1×10⁻⁷	6×10⁻³	3×10⁻⁹	2×10⁻²
	Pm 149	S	3×10⁻⁷	1×10⁻³	1×10⁻⁸	4×10⁻³
		I	2×10⁻⁷	1×10⁻³	8×10⁻⁹	4×10⁻³
Protoactinium (91)	Pa 230	S	2×10⁻⁹	7×10⁻⁸	6×10⁻¹¹	2×10⁻³
		I	8×10⁻¹⁰	7×10⁻⁸	3×10⁻¹¹	2×10⁻³
	Pa 231	S	1×10⁻¹³	3×10⁻⁵	4×10⁻¹⁶	9×10⁻⁴
		I	1×10⁻¹⁰	8×10⁻⁴	4×10⁻¹³	2×10⁻³

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
Protoactinium (91)	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^{-6}	6×10^{-11}	7×10^{-7}
		I	2×10^{-10}	1×10^{-6}	8×10^{-12}	4×10^{-8}
	Ra 224	S	5×10^{-9}	7×10^{-5}	2×10^{-10}	2×10^{-6}
		I	7×10^{-10}	2×10^{-6}	2×10^{-11}	5×10^{-8}
	Ra 226	S	3×10^{-11}	4×10^{-7}	2×10^{-12}	3×10^{-8}
		I	5×10^{-11}	9×10^{-9}	2×10^{-12}	3×10^{-8}
	Ra 228	S	7×10^{-11}	8×10^{-7}	2×10^{-12}	3×10^{-8}
		I	4×10^{-11}	7×10^{-9}	1×10^{-12}	3×10^{-8}
Radon (86)	Rn 220	S	3×10^{-7}	.....	1×10^{-9}	.....
		I	.....	.....	.....	.....
	Rn 222	S	1×10^{-7}	.....	3×10^{-9}	.....
		I	.....	.....	.....	.....
Rhenium (75)	Re 183	S	3×10^{-6}	2×10^{-3}	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^{-4}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-4}
	Re 187	S	9×10^{-6}	7×10^{-3}	3×10^{-7}	3×10^{-3}
		I	5×10^{-7}	4×10^{-3}	2×10^{-8}	2×10^{-3}
	Re 188	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-4}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-4}
Rhodium (45)	Rh 103m	S	8×10^{-5}	4×10^{-1}	3×10^{-6}	1×10^{-2}
		I	6×10^{-6}	3×10^{-1}	2×10^{-7}	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^{-4}	2×10^{-9}	2×10^{-5}
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^{-6}	1×10^{-2}	2×10^{-7}	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^{-7}	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^{-7}	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^{-7}	3×10^{-3}	[illegible]	[illegible]
		I	4×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}

See footnotes at end of table.

*Revised 29 FR 14414

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
* Strontium (38)	Sr 89	S	3×10^{-8}	4×10^{-4}	[illegible]	3×10^{-4}
		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^{-4}	9×10^{-9}	3×10^{-5}
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}
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^{-6}	5×10^{-3}	4×10^{-7}	2×10^{-3}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
	Tc 98m	S	4×10^{-6}	2×10^{-1}	1×10^{-7}	6×10^{-3}
		I	1×10^{-6}	8×10^{-3}	5×10^{-7}	3×10^{-3}
	Tc 99	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	3×10^{-4}
		I	6×10^{-9}	5×10^{-3}	2×10^{-9}	2×10^{-4}
Tellurium (52)	Te 125m	S	4×10^{-7}	3×10^{-3}	1×10^{-8}	2×10^{-4}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
	Te 127m	S	1×10^{-7}	2×10^{-3}	5×10^{-9}	6×10^{-5}
		I	4×10^{-8}	2×10^{-3}	1×10^{-9}	5×10^{-5}
	Te 127	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-4}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Te 129m	S	8×10^{-8}	1×10^{-3}	3×10^{-9}	3×10^{-5}
		I	3×10^{-8}	6×10^{-4}	1×10^{-9}	2×10^{-5}
	Te 129	S	5×10^{-8}	2×10^{-3}	2×10^{-7}	8×10^{-5}
		I	4×10^{-8}	2×10^{-3}	1×10^{-7}	8×10^{-5}
	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}	6×10^{-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^{-6}	2×10^{-2}	9×10^{-8}	6×10^{-4}
Thorium (90)	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}	10^{-5}
	Th 230	S	2×10^{-12}	5×10^{-5}	8×10^{-14}	2×10^{-6}
		I	10^{-11}	9×10^{-4}	3×10^{-13}	3×10^{-5}
	Th 232	S	3×10^{-11}	5×10^{-4}	10^{-12}	2×10^{-5}
		I	3×10^{-11}	10^{-3}	10^{-12}	4×10^{-5}
	Th natural	S	3×10^{-11}	3×10^{-4}	10^{-12}	10^{-5}
		I	3×10^{-11}	3×10^{-4}	10^{-12}	10^{-5}
	Th 234	S	6×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	3×10^{-9}	5×10^{-4}	10^{-9}	2×10^{-5}
Thulium (69)	Tm 170	S	4×10^{-9}	1×10^{-3}	1×10^{-9}	5×10^{-5}
		I	3×10^{-9}	1×10^{-3}	1×10^{-9}	5×10^{-5}
	Tm 171	S	1×10^{-7}	1×10^{-3}	4×10^{-9}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
Tin (50)	Sn 113	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	9×10^{-5}
		I	8×10^{-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}	8×10^{-4}	3×10^{-9}	2×10^{-5}
Tungsten (Wolfram) (74)	W 181	S	2×10^{-6}	1×10^{-2}	[illegible]	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}

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND—continued

[See notes at end of appendix]

Element (atomic number)	Isotope		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
Tungsten (Wolfram) (74)	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	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	8×10^{-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	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-natural	S	7×10^{-11}	5×10^{-4}	3×10^{-12}	2×10^{-5}
		I	6×10^{-11}	5×10^{-4}	2×10^{-12}	2×10^{-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^{-6}	.....	4×10^{-7}	.....
	Xe 133	Sub	1×10^{-6}	.....	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}
Zinc (30)	Zn 65	S	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
		I	6×10^{-8}	3×10^{-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^{-3}	2×10^{-7}	2×10^{-4}
		I	9×10^{-6}	5×10^{-3}	3×10^{-7}	2×10^{-4}
Zirconium (40)	Zr 93	S	1×10^{-7}	2×10^{-3}	4×10^{-9}	8×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
	Zr 95	S	1×10^{-7}	2×10^{-3}	4×10^{-9}	6×10^{-5}
		I	3×10^{-8}	2×10^{-3}	1×10^{-8}	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}

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

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

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

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

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

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

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

a. For purposes of Table I, Col. 1—1×10^{-12} μc/ml
b. For purposes of Table I, Col. 2—3×10^{-7}
c. For purposes of Table II, Col. 1—4×10^{-13}
d. For purposes of Table II, Col. 2—1×10^{-7}

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

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c. Element (atomic number) and isotope	Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
If it is known that Sr 90, I 129, Pb 210, Po 210, At 211, Ra 223, Ra 224, Ra 226, Ac 227, Ra 228, Th 230, Pa 231, Th 232, and Th-nat are not present	.....	9×10^{-4}	.....	3×10^{-4}
If it is known that Sr 90, I 129, Pb 210, Po 210, Ra 223, Ra 226, Ra 228, Pa 231, and Th-nat are not present	.....	6×10^{-4}	.....	2×10^{-4}
If it is known that Sr 90, Pb 210, Ra 226 and Ra 228 are not present	.....	2×10^{-4}	.....	6×10^{-7}
If it is known that Ra 226 and Ra 228 are not present	.....	3×10^{-4}	.....	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^{-9}	.....	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 236, Pu 239, Pu 240, Pu 242, and Cf 249 are not present	3×10^{-10}	.....	1×10^{-10}	.....
If Pa 231, Pu 239, Pu 240, Pu 242 and Cf 249 are not present	2×10^{-10}	.....	7×10^{-14}	.....

4. If the mixture of radionuclides consists of uranium and its daughter products in ore dust prior to chemical processing of the uranium ore, the values specified below may be used in lieu of those determined in accordance with paragraph 1 above or those specified in paragraphs 2 and 3 above.

a. For purposes of Table I, Col. 1—1×10^{-10} μc/ml gross alpha activity; or 2.5×10^{-11} μc/ml natural uranium; or 75 micrograms per cubic meter of air natural uranium.

b. For purposes of Table II, Col. 1—3×10^{-11} μc/ml gross alpha activity; or 8×10^{-12} μc/ml natural uranium; or 3 micrograms per cubic meter of air natural uranium.

5. For purposes of this table, 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 ¼ i.e.

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

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Appendix B from 25 FR 10914 except as otherwise noted.

Appendix C

Radioactive Material	Column A Not as a Sealed Source (uc)	Column B As a Sealed Source (uc)	Column C Maximum Body Burden Whole Body (uc)
Antimony (Sb 124)	1	10	20
Arsenic 76 (As 76)	10	10	300
Arsenic 77 (As 77)	10	10	80
Barium 140-Lanthanum 140 (Ba-La 140)	1	10	9
Beryllium (Be 7)	50	50	600
Cadmium 109-Silver 109 (Cd-Ag 109)	10	10	200
Calcium 45 (Ca 45)	10	10	200
Carbon 14 (C14)	50	50	400
Cerium 144-Praseodymium (Ce-Pr 144)	1	10	20
Cesium-Barium 137 (Cs-Ba 137)	1	10	30
Chlorine 36 (Cl 36)	1	10	80
Chromium 51 (Cr 51)	50	50	800
Cobalt (Co 57)	20	20	200
Cobalt 60 (Co 60)	1	10	10
Copper 64 (Cu 64)	50	50	80
Europium 154 (Eu 154)	1	10	20
Fluorine 18	50	50	20
Gallium 72 (Ga 72)	10	10	10
Germanium 71 (Ge 71)	50	50	2000
Gold 198 (Au 198)	10	10	30
Gold 199 (Au 199)	10	10	100
Hydrogen 3 (Tritium) (H 3)	250	250	2000
Indium 114 (In 114)	1	10	20
Iodine 131 (I 131)	10	10	50
Iridium 192 (Ir 192)	10	10	20
Iron 55 (Fe 55)	50	50	3000
Iron 59 (Fe 59)	1	10	20
Krypton (Kr 85)	10	10	--
Lanthanum 140 (La 140)	10	10	10
Manganese 52 (Mn 52)	1	10	9

Radioactive Material	Column A Not as a Sealed Source (uc)	Column B As a Sealed Source (uc)	Column C Maximum Body Burden Whole Body (uc)
Molybdenum 99 (Mo 99)	10	10	40
Nickel 59 (Ni 59)	1	10	3000
Nickel 63 (Ni 63)	1	10	900
Niobium 95 (Nb 95)	10	10	40
Palladium 109 (Pd 109)	10	10	50
Palladium 103-Rhodium 103 (Pd-Rh 103)	50	50	300
Phosphorus 32 (P 32)	10	10	30
Plutonium 239 (Pu 239)	1	1	0.4
Polonium 210 (Po 210)	0.1	1	0.4
Potassium 42 (K-42)	10	10	10
Praseodymium 143 (Pr 143)	10	10	60
Promethium 147 (Pm 147)	10	10	300
Radium & (daughters)	0.1	1	0.09
Rhenium 186 (Re 186)	10	10	50
Rhodium 105 (Rh 105)	10	10	100
Rubidium 86 (Rb 86)	10	10	30
Ruthenium 106-Rhodium 106 (Ru-Rh 106)	1	10	10
Samarium 153 (Sm 153)	10	10	70
Scandium 46 (Sc 46)	1	10	20
Silver 105 (Ag 105)	1	10	30
Silver 111 (Ag 111)	10	10	50
Sodium 22 (Na 22)	10	10	10
Sodium 24 (Na 24)	10	10	7
Strontium 89 (Sr 89)	1	10	40
Strontium 90-Yttrium 90 (Sr-Y 90)	0.1	1	20(2 Bone)
Sulfur 35 (S 35)	50	50	400
Tantalum 182 (Ta 182)	10	10	20
Technetium 96 (Tc 96)	1	10	10
Technetium 99 (Tc 99)	1	10	200
Tellurium 127 (Te 127)	10	10	80

Radioactive Material	Column A Not as a Sealed Source (uc)	Column B As a Sealed Source (uc)	Column C Maximum Body Burden Whole Body (uc)
Tellurium 129 (Te 129)	1	10	20
Thallium 204 (Tl 204)	50	50	80
Thorium (natural)	50	50	0.07
Tin 113 (Sn 113)	10	10	60
Tritium (See H^3)			
Tungsten 185 (W 185)	10	10	100
Uranium (natural)	50	50	0.2
Uranium 233 (U 233)	1	10	0.4
Uranium 234-235 (U 234-235)	50	50	0.4
Vanadium 48 (V 48)	1	10	10
Yttrium 90 (Y 90)	1	10	20
Yttrium 91 (Y 91)	1	10	30
Zinc 65 (Zn 65)	10	10	60
Beta and/or Gamma emitting by product material not listed above	1	10 (see note 1a below)	
Unidentified radioactive materials or any of the above in unknown mixtures	0.1	1 (see note 1b below)	

Note 1: The preceding table includes all radioisotopes listed in:

a. Appendix B 10CFR30, and Paragraphs 4.6 and 5.18 of the New Jersey Radiation Protection Code. These quantities are those referred to as "generally licensed quantities" sometimes called "exempt".

b. Appendix C of 10CFR20 and Paragraph 11.9 of the New Jersey Radiation Protection Code. The quantities listed in Column A are those specified in the Requirements for Posting, Labeling and Disposal.

c. A table of "Maximum Body Burdens" taken from the "Report of the International Committee on Radiation Protection: Committee II on Permissible Dose for Internal Radiation", 1959, published in Health Physics Vol. 3, June 1960. The values listed are those specified for soluble compounds and specified for the whole body.

Note 2: For purposes of Section IV, 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, in the table, for the specific isotope when not in combination. The sum of such ratios for all the isotopes in the combination may not exceed "1" (i.e., "unity").

Example: If an individual holds a Limited Possession Number for 200 μc of C^{14} and 1 mc of H^3 he must apply for an Authorization Number in order to possess more than 100 μc of S^{35}. This is determined as follows:

$$\frac{200\ \mu c\ C^{14}}{500\ \mu c} + \frac{1000\ \mu c\ H^3}{2500\ \mu c} + \frac{100\ \mu c\ S^{35}}{500\ \mu c} = 1$$

The denominator in each of the above ratios was obtained by multiplying figures in the table by 10 as provided in Section IV B.

Note 3: For purposes of Section VIII and Appendix I, 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 (in the table) otherwise established for the specific isotope when not in combination. The sum of such ratios for all the isotopes in the combination may not exceed "1" (i.e., "unity").

Example: If a particular room contains open sources comprised of 125 uc of S^{35} and 250 uc of C^{14}, it must then be posted if more than 25 uc of P^{32} is obtained. This limit was determined as follows:

$$\frac{125 \text{ uc } S^{35}}{500 \text{ uc}} + \frac{250 \text{ uc } C^{14}}{500 \text{ uc}} + \frac{25 \text{ uc } P^{32}}{100 \text{ uc}} = 1$$

The denominator in each of the above ratios was obtained by multiplying the figure in the table by 10 as provided in Section VIII C. (For Section XI.B. the denominator would be multiplied by 1/10.)

Appendix D

Maximum Permissible Exposures (Occupational)

A. The maximum permissible dose (MPD) as established by the A.E.C., 10 CRF 20, and the New Jersey Radiation Protection Code is as follows:

		Rem Per Calendar Year	Rem Per Calendar Quarter
1.	Whole body exposure; head and trunk; active blood-forming organs; lens of eyes, or gonads.	5	1-1/4
2.	Hands and forearms; feet and ankles.	75	18-3/4
3.	Skin of whole body.	30	7-1/2

B. Internal occupational exposures are limited by establishing controls over the concentration of airborne radioactive materials. The limits are specified in Table I Appendix B. The limits set forth in Appendix B are based on a 40 hour week and an adjustment shall be made in the concentration limits if the number of exposure hours is either greater or less than 40 in any seven consecutive days.

C. The permissible exposures limits for minors, persons under 18 years of age, are as follows:

1. exposure limits for external radiation are limited to 10% or less of the limits specified in paragraph A above.

2. exposure limits to airborne concentrations are those specified in Table II Appendix B. The concentration may be averaged over periods not greater than one week.

D. Permissible levels of Radiation in unrestricted areas are:

1. 2 millirem in any one hour,

2. 100 millirem in 7 consecutive days if continuously present.

E. Permissible concentrations in effluents released (air and water) to unrestricted areas are as follows:

1. those concentrations specified in Table II Appendix B. The concentration limits may be averaged over one year. This Paragraph does not apply to disposals to the sanitary sewer.

F. None of the limits in this appendix are to be interpreted as applying to the intentional exposures of patients to radiation for the purpose of diagnosis or therapy.

Appendix E

Useful Health Physics Forms

A. Convenient forms for the required records and reports should be obtained from the Health Physics Office. The forms are indexed as Health Physics Forms and numbered. Please use forms of the most recent vintage.

B. Departmental Representatives should have the following forms:

	No.	Date	Title
Health Physics	1	6/65	Pre-Employment History and Statement of Agreement
"	2	8/64	Letter--Request for Previous Occupational Exposure Record
"	4	11/65	Statement of Training
"	20	11/65	Application for Isotope Authorization Number
"	30	5/65	Application for Irradiation Authorization Number
"	55	5/65	Application for Limited Possession Number

C. Responsible Investigators should have the following forms:

	No.	Date	Title
Health Physics	5	7/65	Monthly Radioisotope Inventory
"	6	4/63	Radioisotope Inventory
"	11	3/65	Radioactive Waste Disposal-Sanitary Sewer
"	12	4/64	Accident--Spill Emergency Procedures

	No.	Date	Title
Health Physics	12A	2/66	Health Physics Officers Names and Phone Numbers
"	29	8/63	Isotope Transferral Form
"	31	4/64	Emergency Directory and Instructions
"	34	8/64	Radioactive Waste Record

Appendix F

Some Shipping Regulations

A. The regulations governing rail, highway, water and air shipment of radioactive materials have been developed piecemeal over many years to meet a variety of situations. In addition, new regulations are being promulgated at an increasing rate and the old ones are being revised. For these reasons any attempted abstract of the regulations runs the risk of misleading oversimplifications. The following comments are intended as a guide for preliminary planning - final details should be checked with the "Health Physics Officer" at the earliest possible date.

B. Since the ICC regulations are common to most other government regulations the following ICC provisions are provided subject to the qualification indicated above.

1. The contents of the package must be certified as correctly described as to isotope and quantity on the shipping documents and on shipping label (Class D poison).

2. The package must be externally free of loose contamination.

3. Penetrating radiation from the package must not exceed 200 mrem/hr at the surface nor 10 mrem/hr at one meter as measured from the source position within the package at any time during shipment.

4. Liquids must be in an inner container surrounded by a sufficient amount of absorbent and chemically resistant material to take up the entire liquid volume in case of breakage of the inner container.

5. The outer container must be one of several types closely described by the regulations, approved for radioactive materials. No dimension may be less than 4 inches.

6. Regardless of the choice of outer container, any materials of biologically significant retention (Pu, Ra, Sr. etc.) must be in an inner container of closely specified iron or brass construction.

7. Any vehicle used for the transportation of radioactive material must be marked or placarded "Dangerous Radioactive Materials", on each side and the rear, in letters at least three inches higher on a contrasting background, in addition no more than 40 radiation units are permitted in one vehicle. A radiation unit defined as 1 mr/hr at 1 meter from the source position inside the package.

C. ICC exempt quantities and/or package - radioactive materials are exempt from ICC prescribed packaging, marking and labeling requirements provided they fulfill all the following conditions.

1. The package must be such that there can be no leakage of radioactive material under conditions normally incident to transportation.

2. The package must contain not more than 0.1 millicuries of radium or polonium or that amount of Sr^{89}, Sr^{90}, or Ba^{140} which disintegrates at a rate of more than 5 million atoms per second (0.135 mc) or that amount of any other radioactive substance which disintegrates at the rate of 50 million atoms per second (1.35 mc).

3. The package must be such that no significant alpha, beta, positron, or neutron radiation is emitted from the exterior

surfaces of the package (or from within) and the X or gamma radiation at any surface of the package must be less than 10 mr in 24 hours (0.42 mr/hr).

D. Transportation of radioactive materials through the mails is limited by Post Office regulations to those quantities which are exempt from labeling under ICC regulations. Post Office packaging requirements are the same as those of the ICC for exempt quantities.

E. Other agencies involved in the regulation of transportation of radioactive materials include:

1. Federal Aviation Agency
2. U.S. Coast Guard
3. Civil Aeronautics Board
4. New Jersey State Department of Health
5. New York State Department of Labor
6. Port of New York Authority
7. Department of Health New York City
8. New York Thruway Authority
9. New Jersey Thruway Authority
10. Triborough Bridge and Tunnel Authority
11. New Jersey Highway Authority

Appendix G

Compliance with Governmental Regulations

A. All users of AEC by-product materials are subject to the regulations in 10 CFR 20 and 10 CFR 30. In addition, those laboratories using source materials or special nuclear materials are subject to 10 CFR 40 or 10 CFR 70.

B. Laboratories and users situated in the State of New Jersey are also subject to the regulations contained in the newly revised New Jersey Radiation Protection Code which became effective February 1, 1965.

C. All users operating under a major AEC contract are bound to the AEC manual through the Safety, Health and Fire Protection clause in the contract which reads in part, "The (signatories) shall take all reasonable precautions in the performance of the work under this contract to protect the health and safety of employees and members of the public and to minimize danger from all hazards to life and property, and shall comply with all pertinent health, safety, and fire protection regulations and requirements (including reporting requirements) of the commission communicated to the (Signatories) etc." At present this clause and the AEC manual applies to the Princeton Pennsylvania Accelerator and Project Matterhorn.

Appendix H

Processing of an Application for an Authorization or Limited Possession Number

A. Authorization Numbers (Isotope and Irradiation).

1. The applicant obtains the necessary forms and discusses his proposal with his Departmental Representative.

2. The applicant sould consult the "Health Physics Officer" for an explanation of the various regulations and Health Physics services which are available.

3. The applicant takes the completed application to his Departmental Representative. If the Departmental Representative approves of it he signs it and the applicant forwards it to the Health Physics office.

4. The "Health Physics Officer" studies and examines the application and either approves, rejects, or conditionally approves it. This decision is based on the information presented on the application, the statement of training and the previous experience of the applicant.

5. If the application is approved by the Head of the Health Physics Group, two copies are sent to each available member of the U.R.S.C.

6. The individual U.R.S.C. members may approve or reject the application. In any case, he returns one signed copy of the application to the Health Physics office with any pertinent remarks.

7. When the replies are received from all available members of the U.R.S.C. they are sent to the chairman of the U.R.S.C. He reviews the application and he may send a note (H.P. Form #23) to the Health Physics Group requesting that an "Authorization Number"be issued to the applicant.

8. The Health Physics Group will fill in the authorization number on the original and send a copy to the applicant.

9. If the application is rejected the applicant may take his request before a meeting of the U.R.S.C. A request for such a meeting should be made to the head of the Health Physics Group.

10. Applicants are advised that this process may take several weeks and that such application should be made sufficiently in advance of the planned starting date to avoid any crisis.

B. Limited Possession Numbers - The same Procedure is followed as that outlined above in steps one through eight except that steps 5, 6, 7 are omitted.

Appendix I

Posting, Labeling Tagging and Signaling Requirements

A. Each laboratory or group of laboratories under the supervision of a "Responsible Investigator" using sources of radiation must be posted or otherwise provided with the following:

1. 10 CFR 20 as amended,

2. 10 CFR 30 as amended,

3. AEC License No. 29-5185-24 as amended,

4. Princeton University Radiation Safety Guide,

5. AEC Form #3, "Notice to Employees" (must be posted). Contract areas must also post AEC Form #9, "Notice to Employees",

6. In addition, laboratories where Source Material is used - 10 CFR 40 and AEC License SUD #381,

7. In addition, laboratories where Special Nuclear Materials are used 10 CFR 70 and AEC License SNM #356,

8. In addition, laboratories where materials licensed by the state of New Jersey are present - N.J. Radiation Protection Code Form RH-D 14, "Notice to Employees" (must be posted),

9. H.P. Form #12 - Emergency Procedures and Health Physics Officers' phone numbers, (must be posted),

10. H.P. Form #31 - Emergency Phone Numbers and Instructions,

It is further required that all personnel working with radioactive materials and/or radiation, or frequenting a restricted area

be familiarized with the provisions of these regulations.

B. All signs, labels, tags and signals used to indicate the presence of radioactive materials or radiation, shall conform with 10 CFR 20.

Note: Some commercially available items do not meet these government Specifications.

C. Posting of Radiation Areas

1. Each "Radiation Area" as defined in Section II shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words:

CAUTION

RADIATION AREA

2. Each High Radiation Area as defined in Section IIF shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words:

CAUTION

HIGH RADIATION AREA

Note: Access to "High Radiation Areas" shall be interlocked in such a manner that 1) the radiation level is reduced to the point that the person(s) entering the area shall absorb less than 100 mrem/hr, or 2) a visible and/or audible signal shall make the individual and the supervisor of the activity (experiment, radiation producing machine, etc.) aware of the entry and the existing danger.

3. Each "Airborne Radioactivity Area" as defined in Section II shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words:

CAUTION

AIRBORNE RADIOACTIVITY AREA

D. Posting of Areas Containing Radioactive Materials. Each entrance to areas or rooms in which radioactive material is used or stored in an amount greater than 10 times that listed in Column A of Appendix C shall be conspicuously posted with a sign bearing the radiation caution symbol and the words:

CAUTION

RADIOACTIVE MATERIAL

E. Labeling of Equipment and Containers

1. Any equipment (vaults, refrigerator etc.) or container in which radioactive material is transported, stored or used, in an amount greater than that listed in Column A of Appendix C, (except for U-nat, and Th-nat., in which case the amount need be 10 times that listed) shall bear a durable, clearly visible label bearing the radiation caution symbol and the words:

CAUTION

RADIOACTIVE MATERIAL

The label shall also identify the isotope, the amount in curie units, and the date of assay. The outside of a shielded container must also bear this label as well as the inner container.

2. Labels are not required on laboratory containers such as beakers, flasks, test tubes, etc. used transiently in laboratory procedures, or if the concentration of the radioactive material in the container does not exceed that specified in Table I, Appendix B.

F. Tagging of Sealed Sources. All sealed radioactive sources shall bear a durable, legible and visible tag permanently attached to the source. The tag shall be at least one inch square, shall bear the standard radiation symbol and at least the following:

CAUTION - RADIOACTIVE MATERIAL - DO NOT HANDLE -
NOTIFY CIVIL AUTHORITIES IF FOUND

Note: Such tags are available from the Health Physics Group. For sources of such design that tagging is not feasible or desirable, pressure sensitive tape is available with the proper inscription.

G. Radiation Actuated Alarms and/or Interlocks. When radiation producing set-ups (e.g., X-ray machines, particle accelerators, multi-curie sources, reactors, etc.) may produce large, unscheduled amounts of radiation because of human errors or equipment malfunction, the provisions of Paragraph C2 shall apply.