726762

1627

REPOSITORY Oak Ridge Ops. Records Holding Area
COLLECTION Docs. 1944-54
BOX No. H-122-2 Bldg. 2714-H
FOLDER 19 of 49 Chief Counsel HRE 67

ATOMIC ENERGY COMMISSION

A Memorandum for Information

ISOTOPE DISTRIBUTION

Report by the Director, Division of Research and the Chief, Isotopes Division

THE PROBLEM

1. To discuss the future extent of government participation and the opportunities for developing commercial participation in the isotopes distribution program.

BACKGROUND

2. The isotopes distribution program was initiated in 1946 under the Manhattan Project. An interim Advisory Committee on Isotope Distribution was appointed from nominations made by the president of the National Academy of Sciences. This Committee of outstanding scientists was formed for the purpose of recommending policies and aiding in establishing arrangements for distribution of radioisotopes. The order of priority adopted at that time for the allocation of materials and production effort was established according to the intended use as follows:*

a. Publishable researches in the fundamental sciences, including human trace applications, requiring relatively small samples.

b. Therapeutic, diagnostic and tracer applications in human beings and publishable researches in the fundamental sciences requiring larger samples.

*As announced in Science, June 14, 1946, Vol. 103, No. 2685.

1184146

c. Training and education by accredited institutions in techniques and applications of radioisotopes.

d. Publishable researches in the applied sciences.

Allocation of radioisotopes for routine commercial applications was to be deferred until experience ha been gained in supplying the above research needs.

3. Establishment of a priority policy was necessary because radioisotopes were not in routine production; development work was being done in restricted areas along side of highly classified work; little information had been declassified; production and sales groups had not been organized. There was no experience by which costs, needs, or results could be measured.

4. Artificially produced radioisotopes were not new. They had been produced by cyclotrons but in minute quantities. Production of radioisotopes in a nuclear reactor multiplies their availability thousands of times. Radioisotopes are produced in a nuclear reactor by two processes: the fission of U 235 nuclei which maintains the chain reaction; and neutron absorption by nonfissionable target materials placed in the reactor. The radiomaterials are distributed either as unprocessed irradiated material or as chemically processed radioisotopes.

a. All fission products are chemically processed before sale; that is, they are separated from the uranium and plutonium and usually from each other.

b. Radioisotopes from target materials are sold as unprocessed "irradiated units" (definite size batches of irradiated material) or as chemically processed radioisotopes. In the first case processing is

1184747

done by the user or by a secondary supplier. As another alternative the applicant may supply the target material and obtain an irradiation service.

c. Processed radioisotopes distributed by Commission facilities are available primarily in simple chemical forms; for example, Carbon 14 is sold as barium carbonate, Phosphorous 32 as phosphoric acid, Iodine 131 as iodide in sodium sulfite solution. (It was recognized at the start of the program that Commission facilities could not endeavor to supply all the various compounds that different users might require.)

In summary the simple basic products available from Commission facilities may be listed as follows:

a. Irradiated materials
   (1) targets furnished by applicant
   (2) routinely irradiated batches or "units"
b. Chemically processed radioisotopes
   (1) from target materials
   (2) from uranium (fission products)

5. The success of the program became apparent almost immediately after its inception. The Monsanto Chemical Company, and Carbide and Carbon Chemicals Company, as contractor operators of Oak Ridge National Laboratory, accelerated the program by increasing production capacity, constructing new processing facilities, and forming efficient production and distribution organizations. Within 12 months the priority system originally established was no longer necessary. Except for certain separated fission products and high specific activity materials, all orders placed for radiomaterials have been filled within reasonable delivery schedules.

1184748

6. On January 7, 1947, the Atomic Energy Commission assumed responsibility for the atomic energy program including the isotopes distribution program. In establishing the Commission the Congress specifically recognized the desirability of radioisotope distribution in the following sections of the Atomic Energy Act of 1946: Section 3(a) directs the Commission to make arrangements for the conduct of research and development activities relating to the utilization of radioactive materials; Section 4(d) authorizes the irradiation of materials for the purpose of increasing the supply of radioactive materials; Section 5(c) authorizes the distribution of by-product materials (radioisotopes); and Section 12(a)(2) authorizes the Commission to establish regulations, standards and instructions for the use of byproduct materials.

7. The first formal attempt to encourage industry to participate in the program was a "Conference on Commercial Distribution of Isotope-Labeled Compounds" held in Oak Ridge, October 30, 1947. This conference resulted in a report to the Commission (AEC-108 approved June 2, 1948) which established:

a. The availability of radioisotopes for commercial use and commercial resale.

b. A policy acceptable to industry on patents and reports related to isotope utilization.

c. A policy on prices to recover costs of final preparation, not including amortization of the investment in equipment and nuclear reactors.

d. The policy whereby Commission facilities would withdraw from manufacture and general distribution of any labeled compound when it became available from a private firm.

1184749

8. Subsequent to adoption of the policies noted in paragraph 7 the Isotopes Division actively encouraged free enterprise in the following areas related to the isotopes distribution program:

a. Manufacture of radiation measuring and monitoring instruments.

b. Manufacture of special isotope handling and processing equipment.

c. Modification of simple basic products and synthesis of isotope labeled compounds.

d. Analytical research and development services.

e. Consultation services.

f. Manufacture and servicing of devices whose function depends on radioactivity.

9. It was recognized early in the program that greater commercial participation in activities related to isotopes distribution, as well as greater utilization by industry, was limited mainly by the lack of personnel trained in radioactivity techniques. This problem of the lack of training has been more acute in the industrial field than in medical and scientific research. The Isotopes Division was instrumental in the establishment in June 1948 of training courses in radioisotope techniques by the Oak Ridge Institute of Nuclear Studies. Encouragement was given to candidates from industrial laboratories to attend these courses. Encouragement was also given to the organization of various symposia on industrial utilization of isotopes. As a result a noticeable increase has become evident in radioisotope applications from industrial concerns.

10. The first staff review of the isotopes program was held in Washington, March 4, 1949*. The agenda for the meeting was entitled "Present and Future Scope of the Isotope Distribution Program".* Item 4 of the agenda is a discussion

*(See Appendix A) 1184750

of the Government's part in the promotion of isotope utilization by industry. The General Manager and Staff recognized that the Commission should continue to encourage commercial participation in the areas listed in paragraph 3 above. At the same time it was recognized that the Commission should continue to participate in areas of enterprise not readily financed by private industry. The two particular areas discussed were (a) production and processing and (b) training. Reactors and processing facilities operated by the Commission for its own essential activities can, with small added cost, produce isotopes for general distribution. Training facilities are normally provided by universities and technical schools, but because of the rapid development of the field of isotope utilization and the high cost of equipment and facilities for the necessary training, these institutions could not immediately meet the need. It was agreed that ORINS should continue to provide training courses and that the Commission should encourage additional training elsewhere.

11. Regulations for the distribution of radioisotopes were approved by the Commission January 25, 1951 (AEC 398) and published in the Federal Register April 13, 1951. One of the considerations which led to publication of the regulations was that such publication would encourage industrial utilization of radioisotopes by providing formal rules with which industrial users can comply. The published regulations outline only the procedure for obtaining radioisotopes from the Commission. Additional regulations concerning further aspects of radioisotope distribution, such as health and safety standards, are in preparation. Because of the monetary costs of compliance with such regulations it is important that industry know the definite standards that must be met.

1184751

12. Publication of regulations has eliminated the necessity for the applicant to file, and frequently amend, an "Acceptance of Terms and Conditions for the Procurement of Byproduct Materials (Radioisotopes.)" Publication and reporting of results of work with radioisotopes, formerly mandatory provisions of the "Acceptance", were modified so that an applicant need report results only at the request of the Commission. Another encouragement to industry is the assurance that applications, correspondence and field visits will be handled by the Commission in such a manner that information of a (company) confiedntial nature will not be disclosed. These modifications allow development of processes and patentable devices of economic interest to the companies concerned. When such matters are involved it is routine practice to mark all correspondence, reports, applications, and supplementary forms and papers, as follows: "CAUTION. Information contained in this document is considered "COMPANY CONFIEDNTIAL" by the applicant and should be treated as such within the AEC."

13. The recent development of a General Authorization for radioisotope procurement also encourages greater use of radioisotopes by commercial firms. A qualified applicant may obtain a General Authorization for any research and development activity and for processing of radiomaterials for resale to authorized users. General authorizations are renewable each calendar year and permit the holder to obtain any radioisotope (except tritium) in any quantity during that term.

14. On December 23, 1947, the Commission approved the establishment of a more permanent Advisory Committee on Isotope Distribution for the purpose of reviewing existing policies and considering new questions of policy which may arise. Annual meetings were held in 1949, 1950 and 1951. In the last meeting, March 26 and 27, 1951, the Advisory Committee declined to express

an opinion concerning the future extent of commercial participation in isotope distribution. However, the following resolution was passed unanimously: "The Committee has great confidence in and gives full approval to the manner in which the Isotopes Division is conducting its operations; and it feels that the present extent of Government participation in isotope distribution and processing is advantageous to isotope users and fair to private enterprise."*

DISCUSSION

15. It is the policy of the Commission to use facilities and talents of private industry wherever possible. The purpose of this report is to acquaint the Commission with the progress that has been made, and the steps proposed for the future, to implement this policy in the field of isotope production and distribution.

16. Five functions contribute to the isotopes distribution program: A. Reactor Production; B. Chemical Processing; C. Sales; D. Control; E. Promotion. The effort of the Commission is directed toward making isotopes as nearly like ordinary items of commerce as possible. The problem encountered in reaching this goal will be discussed separately under each of the main functions.

A. REACTOR PRODUCTION

17. Although the Federal government owns the radioisotope production reactors, the Manhattan Project and the Commission have always followed the policy of operation by private industry. The economic stumbling block to complete private operation of a reactor for radioisotope production is the initial cost of construction. The Manhattan Project staff, at the start of the

*"Minutes of the Third Meeting of the Committee on Isotope Distribution" on file in the Division of Research.

1184753

program, realized that if cost estimates included amortization of the reactor and other major facilities it would make prices of radioisotopes prohibitive. Therefore, the operating contractor (Monsanto Chemical Company) was asked to base prices on the costs of production, including operational costs only: direct expense of personnel, utilities, expendable materials and special equipment plus a factor for indirect expenses included in the normal overhead costs. This policy has been continued by the Carbide and Carbon Chemicals Company, present operators of Oak Ridge National Laboratory. Financial accounts are reviewed periodically to determine whether total revenues and costs are approximately equal. Carbide forecasts a small "profit" by fiscal year 1953. Individual items are not necessarily priced to reflect actual costs - lower cost items such as Iodine 131 and Carbon 14 may be sold at higher than cost to help support lower prices on more costly irradiated materials.

18. It is premature to discuss complete private production at length. The General Manager has negotiated an agreement with the Bendix Aviation Corporation to undertake a study to determine the feasibility of private financing for the construction and operation of a nuclear reactor for the production of radioisotopes (AEC 331/14). Results of the survey will be presented to the Commission upon completion. Copies of the Bendix agreement and a statement of the purpose and scope of the study are on file in the Division of Research. Tracerlab, Inc., has also proposed to make a study of the feasibility of private radioisotope production and of its effect on private processing and use. This latter proposal is to study the problem from the standpoint of a processor rather than a producer. It is obvious that the Commission must supply radioisotopes until private industry is ready and willing to produce them.

1184754

19. Reactor production of radioisotopes cannot be expected to become a freely competitive enterprise in the near future. A single properly designed reactor can completely satisfy the United States needs for reactor irradiated materials. The present Oak Ridge reactor is deficient in meeting the country's needs only because it lacks the high flux required to obtain desirable specific activities; it does, however, have sufficient space and excess neutron capacity to satisfy the needs in terms of total activity for a number of years to come. A reactor such as the Chalk River NRX unit, or the proposed Argonne CP-5 unit, could satisfy the irradiations required for the isotopes distribution program in the foreseeable future.

20. As long as a considerable number of government-owned reactors are in operation they will be the cheapest source of irradiated material. The actual commodity needed to produce radioisotopes is excess reactor neutrons. Present reactors have primary functions other than radioisotope production, hence the excess neutrons available from them are in a very real sense byproducts. In the case of reactors used almost entirely for research purposes, it is not feasible to use the excess neutrons for the production of fissionable materials or other isotopes of military interest. If the neutrons in these reactors are not used for the irradiation of materials of interest to the nation's isotope distribution program, they will be wasted by absorption in control rods.

21. If reactors are privately financed for the production of power and fissionable materials, it is possible that these reactors will also have excess neutrons as byproducts. However, for maximum production of fissionable material and power, these reactors would not have a very large extra neutron irradiation capacity. Furthermore, the operation temperature and the irradiation space

1184755

available would not be suitable for radioisotopes production. The economics of radioisotope production would depend upon the prices paid for fissionable material and power. Private operators of reactors would of course obtain long lived fission products as a byproduct and if a sufficiently large scale demand developed for these, they could conceivably be obtained on a profitable basis during fuel recovery operations. A fission product business of this type might become competitive.

B. CHEMICAL PROCESSING

22. The basic products (paragraph 4) distributed from Commission facilities frequently require further refining, processing or fabrication for investigations and applications in research and development, in medicine, and in industry. The wide variety of uses for radioisotopes have created demands for labeled compounds ranging from special modification of the simple basic compounds, through processing of the major intermediates, to the synthesis of complex compounds required for metabolic studies. Isotope-labeled drugs must be carefully prepared to meet pharmaceutical standards. Special radiation sources and devices must be fabricated for industrial use. Radioisotope processing, and consultation service provide excellent opportunities for small business firms and new enterprise.

23. Commission facilities have been used for the production of irradiated materials and for the processing of these materials into simple most widely usable chemical forms. Although some complex isotope-labeled compounds have been synthesized in Commission laboratories in connection with approved programs, off-project distribution has been limited to sale of those compounds which are not available from private industry (paragraph 7). Three

1184756

projects have been undertaken to encourage industry to enter this field and supply the demands:

a. Research and development contracts have been made with private research groups to develop economical syntheses for the production of important intermediate compounds.

b. A program for purchasing on open bids from private laboratories certain special compounds of particular interest for biological and medical research when the syntheses are difficult and the degree of demand is uncertain. Compounds in this category include such important items as labeled folic acid, thiouracil and hormones needed for cancer research, labeled vitamins and labeled DDT.

c. A "Registry of Isotope-Labeled Compounds" has been established in the Isotopes Division to serve isotope users in two ways: (1) it will permit them to find out the availability of a specific compound and the supplier, and (2) it will give them an opportunity to inform other users of a compound which they have prepared in excess of need and which they are willing to make available.

24. The program of encouraging labeled compound development (paragraph 23 a) is for a short term of three years and will be concluded June 30, 1952. Contractors have agreed to supply compounds they produce for a period of 18 months at prices which do not include costs of development of synthesis procedures. The synthesis procedures are to be made available to all interested parties. There were six contractors participating in the program in fiscal year 1950, eleven in 1951 and seven will participate in 1952. Syntheses will have been developed for a total of 125 or more compounds by the end of the program.

1184757

25. The stockpiling program (paragraph 23 b) is a continuing one. Carbide and Carbon Chemicals Company through the Oak Ridge National Laboratory invites bids from various private and commercial laboratories for multi-millicurie quantities of a particular compound. Once the compound has been synthesized the Laboratory purchases the entire inventory for stockpiling and resale in submillicurie amounts to isotope users. Because of the complexity of the synthesis procedure, it is usually more feasible to synthesize a much larger quantity of the labeled compound than would be required by a single isotope user. Therefore, by serving as the "middle-man" in holding the complete inventory of the compound, the Commission, thru Carbide, serves the interests of both the laboratory making the compound and the isotope user. Oak Ridge National Laboratory charges the user an appropriate price aimed at recovering all direct costs. Once the synthesis procedure for a particular compound has been well developed and the demand has increased to sufficient extent to warrant its routine preparation by a private supplier, the compound is withdrawn from the stockpiling program.

26. The two programs outlined above, together with the "Registry," have shown positive results. Approximately 225 available isotope-labeled compounds are now listed with the Isotopes Division. Detailed synthesis procedures will also be available for most of these compounds. In addition one company alone has listed over 400 simple intermediate-type compounds which it will prepare on order from a customer.

27. Commercial firms have been encouraged to develop the business of refining radiomaterials for biological and medical investigations. Pharmaceutical houses have an opportunity to provide sterile, pyrogen-free and accurately

1184758

measured materials for therapeutic use. Abbott Laboratories, North Chicago, Illinois, and Tracerlab, Inc., Boston, Massachusetts, have been most enterprising in establishing this new business. Abbott Laboratories has completed arrangements with the Roane-Anderson Company to lease a site and operate a plant in Oak Ridge for development and sale of processed radioisotopes for medical use. The principal radioactive pharmaceuticals manufactured by Abbott and to be sold from Oak Ridge are: colloidal gold, diiodofluorescein and iodinated human serum albumin. Radioiodine and radiophosphorous are becoming so widely used in therapy that it is expected they will soon advance from the status of "new drugs" (for experimental use only) into the category of accepted drugs (eligible for listing in the U. S. Pharmacopoeia). Tracerlab has also indicated an interest in greater participation in processing radioactive pharmaceuticals and possible establishment of a processing facility in Oak Ridge.

28. The fabrication and manufacture of devices which depend on radiation for their usefulness is becoming an important industry. A few of the products already developed are: thickness gages, beta-ray applicators, luminescent buttons containing activated phosphors sources for industrial radiography, liquid level indicators, ionizing sources for vacuum tube switches, Cobalt 60 needles as substitutes for radium, multicurie Cobalt 60 teletherapy units as substitutes for X-ray machines, and static eliminators. At least three firms - General Electric, Industrial Nucleonics Corporation and Tracerlab, Inc. - forsee large marketing possibilities for thickness gages alone. The opportunities are unlimited for development of new and economically important controls and devices. The total value of sales involved in such devices is many times greater than the cost of the incorporated radioactivity.

1184759

29. A list of approximately 30 firms which have announced radioisotope services is attached (Appendix B). In addition to the firms or departments which specialize in handling radioactivity there are many private consultants in this field throughout the United States. The journal, "Nucleonics," at the suggestion of the Isotopes Division, has published and will keep current, a register of consultants on radioisotope uses, listed by geographical location and field of specialization.

30. Reactor production and subsequent processing have been closely associated in Commission facilities. However, they are distinct operations and can be separated. For example, the processed isotopes of greater commercial importance (Iodine 131, Phosphorous 32, Carbon 14, Tritium, Gold 198, Sulfur 35, Strontium 90) could be sold only in bulk lots as unprocessed irradiated targets or partially refined fission products to commercial suppliers for processing and resale. It would also be possible for the Commission facilities to continue doing the bulk scale extractions of the widely used basic materials but sell them to secondary suppliers in "wholesale" lots at reduced prices. Secondary suppliers could then compete for the retail business on the basis of services supplied to the ultimate user. Although bulk sales are possible under present procedures, there is no price advantage for the processer. The Isotopes Division is seeking a suitable means by which unprocessed irradiated materials can be sold "wholesale" to commercial processors and the Commission can withdraw from certain "retail" sales activities.

31. If the Commission should choose eventually to retire from supplying chemically processed radioisotopes and sell only irradiated materials, it might then be necessary to exercise some supervision over final prices, or

1184760

to ascertain that competition existed in the processing operations. A detailed economic survey of pricing policy and factors influencing isotope prices will afford the Commission a basis for estimating the effect of commercial processing on prices. If the volume of business in some isotopes does not warrant competition, the government might award contracts for these phases of processing to the firms which would guarantee the lowest prices and most service to users.

32. The chemical processing of reactor irradiated materials to obtain radioisotopes would probably not be a freely competitive business in the very near future. Even a very large amount of radioactivity, e. g., the amount of radioactive iodine per month which the nation might require even five years hence, can readily be prepared by one extraction unit of modest size. For example, the present chemical processing facilities operated by Carbide at Oak Ridge National Laboratory could readily meet from ten to a hundred times the current demand, depending on the isotope.

33. Long-lived fission products present a special situation for they are inescapable byproducts of reactor and uranium fuel recovery operations. In general, fission products are not useful as obtained in bulk waste solutions or process effluents, but would need to be extracted in semi-refined or refined forms. The Commission does not now have a plant for extraction of these substances in very large quantities. If a very large scale demand develops, two courses are open:

a. The government could construct a plant to recover and sell semi-refined fission products to private processing firms. This plant would have to be at a major reactor site and closely associated in both space

118761

and function with the government's plants for uranium waste recovery or plutonium processing. Consequently, it would be most practical for this to be operated by the contractor operating the main process plant. Other firms could purchase semi-refined fission products and do further refining in private plants located near the main process plant or even at a distance. Prices for the semi-refined material would depend on the government's apportionment of costs in the overall recovery process. Prices for refined materials would of course include amortization of privately owned plants.

b. Private companies could be invited to bid on an opportunity to build a plant to extract fission products from uranium recovery or plutonium process effluents. This would need to be a classified operation and security clearance would be needed for those desiring to bid. At first, the successful bidder would have a private monopoly. He should thus be required to sell partially refined fission products at "wholesale" prices as well as refined products at "retail" prices. Other companies could then compete for the business of selling final purified products or packaged radiation sources. Eventually, fission products will be available from many reactor sources and if the demand is sufficiently large, the business could become freely competitive.

34. The question of large scale utilization of fission products by industry is the subject of a special study being conducted for the Commission by the Stanford Research Institute. This subject has also been studied by the Isotopes Division and the conclusion reached that two major questions must be resolved.

a. Are the Hanford wastes an economical source of fission products? The problem of refining wastes from Hanford has been studied by the

1184762

ORNL staff and their conclusion is that the wastes resulting from present processing methods cannot be economically recovered. However, Arco and Savannah River Operations could eventually become sources of more easily processed fission products.

b. How much irradiation value will the purchaser receive for the cost? The large scale applications of fission products considered so far, such as sterilization of foods and pharmaceuticals, can possibly be accomplished as well and cheaper by other sources of radiation such as X-ray or electron beams. In comparing the economic advantages and disadvantages, the user will determine which source of radiation will require less cost in construction, maintenance, control, decontamination, and which will be less hazardous in operation.

The results of the Stanford study will be available in August or September and the Commission will have an opportunity to review further the problems of, and the recommendations for, developing the uses of fission products in industry.

35. Certain other problems which arise from the effort to encourage development of the isotope processing business are listed below. They are not discussed in detail but it is clear that each factor must be considered as part of the overall program.

a. Problems for the Commission:

(1) Maintenance of security - in any process connected with handling fission products.

(2) Development of free competition.

(3) Assurance that materials required for small research needs will be supplied, as well as large profit items.

1184763

(4) Method of distribution of unprocessed irradiated materials and fission products in bulk (contract, franchise, sealed bid, etc.)

b. Problems for industry:

(1) Proximity of processing facilities to reactor.

(2) Transportation of high level activity.

(3) Duplication of government facilities for handling fission products. (Commission facilities do the initial extraction of plutonium and gross separation of uranium from fission products.)

(4) Waste disposal.

(5) Opportunity for profit (including consideration for the degree of competition, the extent of the market, possible decrease in demand because of higher prices necessary to provide for amortization of capital equipment).

The Isotopes Division is preparing studies leading to recommendations on the solution of these problems consistent with directives of the Atomic Energy Act and the public interest.

C. SALES

36. The Commission makes no direct sales. Sales and distribution service is provided to the public and secondary suppliers through contractor organizations. The regulations for radioisotope distribution define a distributor as "any person to the extent that such person is engaged in operating Commission-owned laboratories, plants, or other facilities under a contract with the Commission and is engaged in the distribution of radioisotopes for the Commission." Other persons, who make secondary distribution, are referred to as "suppliers." Any person holding a valid authorization for Radioisotope

1184764

Procurement" may approach any distributor or supplier he designates. Arrangements for production, scheduling of shipments, shipment, invoicing and collections are made between the parties.

37. Prices of materials sold from Commission-owned facilities are controlled to insure a fair return to the Government and a reasonable price to the user. Prices are reviewed by the operating contractor at six months intervals and annually by the Advisory Committee. The Division of Research, at the request of the Isotopes Division, is considering a proposal to employ a consulting firm to study the complete pricing structure. Factors influencing prices of radioisotopes are:

a. type of reactor (space, flux, inhours available)

b. cost of reactor and major facilities

c. operating expense

(1) direct costs - labor, materials, utilities

(2) general overhead, including security and health safety

(3) levels of activity handled

(4) clerical and administrative expense

d. volume of sales and demand

e. profit

Present prices of basic materials do not include cost of reactor and major facilities or profit - factors which must be included under any production and distribution plan for a privately built and operated radioisotope reactor.

38. The Commission exercises no control over prices charged by secondary suppliers. Thus far the Commission has not forced users to obtain processed material from an exclusive commercial supplier. Although at present there

1184765

is little competition in the supplying of labeled compounds and modified forms of the basic materials available from Commission facilities, the user is still free to purchase the basic materials from a Commission facility and process them himself. To a considerable extent this acts to limit the prices that can be obtained. In order to gain business ~~secondary~~ suppliers need to demonstrate either that it is more economical to purchase the processed material or that a better product is obtained. This arrangement has proved quite satisfactory and has been accepted as fair by both users and ~~secondary~~ suppliers. Should the Commission wish to retire from retail distribution of the basic processed materials now available from its facilities, that is to sell these materials only wholesale to ~~secondary~~ suppliers, some arrangement would have to be made either to control prices or ensure free competition.

D. CONTROL

39. Radioisotopes in the kinds and quantities producible in a nuclear reactor create health and safety problems in transportation, use, and disposal. These problems are not limited to the individual user but become matters of public interest. In shipping radioisotopes AEC ~~contractors~~ follow Interstate Commerce Commission rules, with respect to shie' ing, packaging and labeleing, for protection of persons coming in contact with radioisotopes. In the use and disposal of radioisotopes by persons receiving them through the AEC, the Commission has a moral as well as legal responsibility to provide such controls (over the use and disposal of radioisotopes) as may be necessary to protect public health and safety and minimize hazards to life and property.

40. Whenever controls are necessary it is preferred to establish them by published regulations and standards. That this is the wish of Congress in

the case of radioisotope distribution is clear from the authority for byproduct (radioisotope) distribution under the Atomic Energy Act and from the requirements of the Administrative Procedures Act as applicable to AEC functions. Federal agencies such as the Interstate Commerce Commission, Food and Drug Administration and others which have statuatory regulatory functions to protect the public from dangers inherent in shipment or use of hazardous or poisonous articles, commonly establish regulations providing definite procedures, restrictions or requirements.

41. To date distribution of radioisotopes under conditions which will insure safe use has been accomplished by means of an allocation or "licensing" procedure. An application form is required giving detailed statements about the isotope, the use, and the equipment and facilities available to the investigator. A procurement authorization is issued only to an applicant who has facilities and experience to observe the safe use of radiomaterials. Radioisotope users with considerable experience may obtain "General Authorizations" good for one year for the procurement of any quantity of all radioisotopes (except tritium), for any research and development use within the applicant institution.

42. One of the most important steps in encouraging commercial processing of radioisotopes as well as their use in industry will be the establishment by the Commission of safety standards to protect health. Only in this way can the total costs of operation and legal responsibilities be evaluated. The Isotopes Division has endeavored to prepare standards which would be approved by health and safety experts and would be acceptable to the public. The first report on safety standards was submitted to the Advisory Committee on Isotope Distribution at the 1950 meeting. The Committee did not approve the recommendations and referred the study to a Subcommittee on Safety Standards. At the 1951 meeting the Subcommittee reported that deliberation and consideration of health

and safety standards should be deferred until publication of recommendations by the Subcommittee on Permissible Internal Dose (of the National Committee on Radiation Protection). At the insistance of the Isotopes Division the Advisory Committee approved "publication in the Federal Register of health and safety standards based on the firm recommendations of the International Committee on Radiation Protection adopted at the Sixth International Congress of Radiology in 1950."* The Isotopes Division is proceeding under this approval and has in preparation a staff report on health and safety standards. The standards and procedures will be coordinated with the National Committee on Radiation Protection, the Division of Biology and Medicine, the Food and Drug Administration, the National Institutes of Health and the Office of the General Counsel.

43. Regulations recently published in the Federal Register apply to procurement procedures only. Additional instructions for inclusion in the regulations are being developed to explain other procedures and rules applicable to specific situations. Examples are:

a. Procedures for withholding and recalling radioisotopes from persons who are not equipped to observe or fail to observe health and safety standards, or who use the materials in a manner other than as disclosed in the application therefor.

b. Procedures for appeal by the applicant from Isotopes Division decision to withhold or recall radioisotopes.

c. Procedures for obtaining authorization for medical use of radioisotopes.

d. Procedures for obtaining a General Authorization.

e. Criteria for safe use of devices containing radioactivity.

*Minutes of the Third Meeting, Advisory Committee on Isotope Distribution.

1184768

Publication of these and additional rules as necessary, will emphasize the Commission's determination to encourage the wider use of reactor-produced radiomaterials as long as any user is willing to abide by recognized standards and procedures.

44. Two fields present special problems for radioisotope control - medical use and manufacture and sale of devices containing radiomaterials. By legislation and regulation the Food and Drug Administration and the National Institutes of Health control the use of drugs and therapeutic devices. (The jurisdiction of the N. I. H. is limited to blood derivatives.) The Isotopes Division staff and representatives of the Office of the General Counsel held a preliminary conference April 25, 1951, with the Medical Division, Food and Drug Administration to discuss the problems of authority and the means of cooperating for the best interests of each agency and the public. Recommendations are being prepared for referral to the General Manager.

45. Agreement has been reached slowly among the experts and between various advisory committees on health and safety standards and official recommendations are not yet available on all phases of radioisotope utilization. Even though this situation prevails it is obvious that some guidance is necessary. Therefore, the Isotopes Division has taken interim measures to make health and safety recommendations available to those organizations particularly concerned with these matters. For example, current reports, reprints, and general information on radiation safety, together with lists of new users, are forwarded each month to:

a. Each state public health or industrial hygiene department, whichever is responsible for radiation safety in the state.

1184769

b. The Joint Casualty Committee on Radiation, Association of Casualty and Surety Companies.

c. The National Photographic Manufacturers Association.

In addition, since disposal of radioactive waste materials has been a problem of major concern to health agencies, a service has been provided for return of such wastes to Commission facilities for safe disposal. A member of the Isotopes Division staff participates actively in the Subcommittee on Waste Disposal and Decontamination of the National Committee on Radiation Protection.

46. The Isotopes Division has recently established a position in the Advisory Field Service Branch with the specific assignment of encouraging and assisting state health organizations to assume the major responsibility for surveillance of radioisotope use and control of radiation hazards. The Advisory Field Service Branch will continue to provide information, assist in evaluating actual or potential health hazards, act as technical referee between state health departments and users, and continue to make occasional inspections of institutions which hold General Authorizations or procure radiomaterials either in large quantities or of a very hazardous classification.

47. The Isotopes Division is also working out details on recommendations for less restrictive procedures for the international distribution of radioisotopes and the distribution of stable isotopes.

a. Staff report 231/13 was prepared with the ultimate objective, approved by the Advisory Committee on Isotope Distribution, of working toward a program which imposes no more restrictions upon a foreign purchaser of radioisotopes than are imposed on a domestic purchaser. This

1184770

report which recommended an increase in the number of available materials and in the uses to which the isotopes might be put was approved by the Commission on January 30, 1951. The industrial features of the program were presented to the Isotopes Division particularly by the General Electric Company, X-Ray Engineering Company, Tracerlab, Inc., and U. S. Radium Company, who want to develop foreign markets for thickness gages labeled compounds, and other products and devices as developed. As a further step toward enhancing foreign markets the Isotopes Division is studying the feasibility of establishing criteria for issuance of General Authorizations to authorized representatives of foreign countries.

b. The Isotopes Division is also proposing to simplify procedures for procurement of stable isotopes. Limited amounts of deuterium and deuterium oxide, for instance, could be distributed both within the United States and abroad without the necessity for filing an application or receiving an approval. At least 90% of the applications approved are for amounts less than 1000 liters of gas or 1000 grams of water and supplies are ample to meet these needs. To continue controls over such quantities is of nuisance value only. Other stable isotopes, especially those concentrated by electromagnetic methods, present more difficult problems because of limited supply and high cost. In compliance with the Administrative Procedures Act the Isotopes Division is preparing procedures and rules for obtaining and using stable isotopes. Regulations for stable isotope distribution will be procedural requirements only, since health and safety standards are not necessary. It will be determined with the Food and Drug Administration whether additional restrictions on human use are necessary or desirable.

48. The Commission, as sole distributor of reactor-produced radioisotopes has been in the unique position of being able to exercise controls at the source of supply. This is accomplished by a procedure involving review of an application for radioactive material and issuance of an authorization for procurement. It has thus been possible to evaluate the degree of adequacy of conditions, both physical and personal, which will surround the use of these hazardous materials. This is in sharp contrast to the distribution system for most other hazardous materials ~~which involves little or no control at the source of supply but leaves all the burden of control~~ until after the materials ~~have been received by users~~. In a very satisfactory way the control of distribution by allocation has prevented any significant misuse of radioisotopes. In view of the present widespread lack of training and knowledge in the handling of all the kinds of radioactive materials available from the Commission it appears that the present system of control is a more desirable procedure than to permit shipment of radioisotopes to any purchaser and to attempt to maintain wholesome working conditions by punitive action against those who violate safe practice. The Isotopes Division feels that at least for a number of years the Commission should continue the present procedures for control of radioisotope distribution and use by prior review of the applicant's equipment, facilities and experience. In addition, measures will be taken to have more and more responsibility for surveillance of health and safety practices exercised by local health officials and insurance agencies.

1184772

E. PROMOTION

49. Control of radioisotope distribution is necessary because of the health and safety aspects; promotion of radioisotope usage is desirable so as to increase the benefits that will come from radioisotope utilization. Promotion, in this field, is accomplished by providing educational material on radioisotopes and possible uses, and by providing information on health and safety.

50. The Commission now promotes the use of radioisotopes by:

a. Public announcements of the availability of isotopes, results achieved by their use, and the distribution policies of the Commission.

b. Publication and distribution of isotope catalogs and informational bulletins such as "Isotopics" that contain information on materials and specifications, policies, procurement procedures, health and safety recommendations.

c. Maintenance of complete reference file of reprints and publications on all techniques and all uses of isotopes.

d. Preparation and presentation of talks, exhibits, public and technical releases.

e. Provision of advisory field service for assistance in undertaking isotope work and for education on health and safety.

f. Financial support of ORINS courses and cooperation with other institutions and agencies which offer isotope technique training.

g. Support of basic research in biology and medicine and the physical sciences, relating to atomic energy and its byproducts.

h. Sponsorship of fellowship programs.

i. Cooperation in the production of technical training films.

j. Publication of reports on the progress of the isotopes program.

51. The rapid growth of the isotopes program is pointed up in the following two tables. The first one shows the increasingly large number of applications handled each year by the Isotopes Division and the second shows the increasing dollar value of shipments made each year by the Carbide and Carbon Chemicals Company.

Table 1 - Isotope Applications Received

Calendar year	Number of Applications			
	Radioisotopes	Stable Isotopes	Export	Total
1946	323	115	-	438
1947	1041	315	14	1,370
1948	1702	456	209	2,367
1949	2760	685	222	3,667
1950	3934	730	209	4,873
	9760	2301	654	12,715

Table 2 - Radioisotope Sales, ORNL

Calendar year	Sales
1946 (5 Mos.)	$ 34,792
1947	162,520
1948	360,238
1949	710,250
1950	819,624
1951: Jan. - May	469,058

The Carbide and Carbon Chemicals Company estimates that revenue from sales will exceed one million dollars in 1952. If the program continues to grow

1184774

at the present rate it can be estimated that the annual sales volume will reach $2,000,000 in about five years hence.

52. Abbott Laboratories (as a "supplier" or secondary distributor) reports that 1093 shipments were made in calendar year 1950. Cumulative figures are not available for shipments from Tracerlab but the total number would probably exceed the Abbott total. Both companies desire to obtain processing facilities and sales offices in Oak Ridge; Abbott, of course, has already completed leasing negotiations. The dollar value of shipments made by secondary suppliers is not known but it could eventually become larger than that of the primary sales. For instance, the cost of a few millicuries of Strontium 90 is very small compared to the price of the Strontium 90 source used in a beta ray applicator or a thickness gage.

53. Although the use of radioisotopes has grown steadily until it is nearly a million dollar a year business it is well to note two facts about the total sales:

a. A maximum of $450,000 of the ORNL sales volume represents a subsidy for the costs of production of radioisotopes distributed free of charge for cancer research. The method determined for handling this subsidy will influence the decision of an industrial firm to undertake private production of radioisotopes. The Commission could (1) remove the subsidy, (2) support cancer research projects by contract or (3) subsidize all production costs regardless of the uses made of the radioisotopes. Radioisotopes have become so widely used in medical research that their use would continue despite removal of the subsidy, although possibly at a retarded rate.

1184775

b. Approximately $200,000 of the ORNL sales volume represents sales to other Commission installations.

Therefore, at least 65% of the ORNL "sales" are supported directly by the Commission. This percentage is actually much higher but figures are not available on the volume of sales made to institutions which are purchasing radioisotopes with funds obtained for research projects through the various Commission Divisions. These factors become very significant in any discussion of extent of government participation in this particular industry.

54. Some 800 shipments of radioisotopes have gone to industrial users. This represents only about 4% of the total of 18,000 shipments made to U. S. users outside Commission facilities for applications in all fields of study. A better indication of the extent of industrial use is that 183 of the 612 receiving institutions, or approximately 30%, are industrial organizations. The reason for this apparent discrepancy is that medical and biological programs use isotopes of short life and thus require frequent shipments whereas industry uses longer lived materials. It is to be noted that the 183 industrial organizations now having used radioisotopes represent a 50% growth over the corresponding number a year ago. Also, in the last 10 months the amount of Cobalt 60 shipped has increased 552% -- due principally to industry's use of this isotope for radiographic testing. Present experience indicates clearly that industrial utilization of radioisotopes will continue to grow rapidly.

SUMMARY

55. It is the Commission's desire to reduce its monopoly in radioisotope production and distribution wherein consistent with directives of the Atomic

1184776

Energy Act and the public interest. Preliminary progress made in this direction is reported in this study. The Division of Research and the Isotopes Division concur in the program outlined below for encouraging further commercial participation in isotope production, distribution and use.

56. The program recognizes that at this time private ownership and operation of a reactor solely for radioisotope production may be remote; that chemical processing is an area which offers immediate opportunities for increased commercial participation (several firms have already entered this field); that certain functions related to sales, control and promotion will remain Commission responsibilities; and that definite published criteria and standards governing utilization will encourage further commercial participation.

a. Reactor Production. (1) Assist the Bendix Aviation Corporation and Tracerlab, Inc., in studies of the feasibility of private construction and operation of nuclear reactors for radioisotope production. (2) Continue to provide adequate use of all contractor-operated Commission reactors until private production is deemed feasible and is undertaken.

b. Chemical Processing. (1) Assist the Stanford Research Institute in its survey of the industrial uses of fission products. (2) Encourage and assist other firms, as Abbott Laboratories and Tracerlab were assisted, to set up laboratories and plants for development and sale of processed radioisotopes. (3) Develop a method for sale of unprocessed irradiated materials in quantity or bulk lots at reduced or wholesale prices to commercial firms for processing and resale. (4) Continue to authorize contractor-operated Commission facilities to provide certain basic, widely-used processed radioisotopes and to develop economical methods

1184777

for processing radioisotopes until these services may become available from commercial processors.

c. Sales. (1) Continue authorization of sales of basic materials through Commission ~~contractors~~ and at approved prices. (2) Provide assurance that all needs for radioisotopes will be met, from small research amounts to large medical or industrial quantities. (3) Protect the public interest in radioisotope prices. (4) Arrange for study of the pricing structure by a private consulting firm experienced in economic surveys.

d. Control. (1) Provide impersonal controls by publication in the Federal Register of procurement procedures for radioactive and stable isotopes and health and safety standards for radioisotopes. (2) Encourage eligible institutions to apply for General Authorizations. (3) Increase the scope of General Authorizations to include medical use and international distribution. (4) Encourage state agencies to accept responsibility for surveillance of radiation safety by providing them with model codes for radiation safety and information and assistance on evaluation of radiation hazards.

e. Promotion. (1) Provide educational material on radioisotope uses and possible uses. (2) Provide information on materials and specifications, policies and procedures. (3) Provide information on health safety in the storage, use and disposal of radioisotopes. (4) Assist in developing and presenting radioisotope technique training courses and the production of training films and other visual aids. (5) Encourage wider application and use of isotopes.

1184778

57. Rather than make generalizations on commercial participation in all areas of the isotopes program, each possible area of participation should be evaluated according to its own particular functional situation. A detailed economic analysis of opportunities for private enterprise made by a non-interested organization, or by several interested firms, will provide the Commission with a basis for a proper and equitable expansion of commercial participation. The surveys by Bendix Aviation, Inc., and Tracerlab, Inc., as well as the proposed study of isotope pricing policies should provide the Commission with a basis for future action.

1184779

AEC, Oak Ridge, Tenn.-6-29-51-50-A-32693

APPENDIX A

Agenda and Minutes

of

General Manager's Staff Meeting

on the

Isotope Program

March 4, 1949

1184780

PRESENT AND FUTURE SCOPE OF ISOTOPE DISTRIBUTION PROGRAM

Prepared by the Isotopes Division for discussion with the General Manager
March 4, 1949

A. General Scope

The Atomic Energy Commission is conducting a broad program for the distribution of radioactive and stable isotopes commensurate with the declared policy of the Government in the Atomic Energy Act to direct the development and utilization of atomic energy toward "improving the public welfare, increasing the standard of living, strengthening free competition in private enterprise, and promoting world peace."

In brief, the program provides for (1) the distribution and utilization of unclassified radioactive and stable isotopes, (2) the development and distribution of isotope-labeled compounds, and (3) the service irradiation of special materials as requested by the applicant. The program involves national distribution, both on and off the Project, and limited international distribution. In line with the related responsibility of setting safety standards for the protection of health, the Commission through the Isotopes Division provides information, consultation and assistance in safe practices in the use of radiomaterials.

The materials and services are offered for use in scientific research, medicine, industry, agriculture, education and other purposes as developed.

The materials and services are made available to qualified applicants with a minimum of red tape and under conditions which encourage their use. The prospective user is required to (1) file an application stating the specific use for the material and the manner in which it will be used. (2) agree to hold the Commission and/or its contractors harmless from claims for damage to materials or persons resulting from the use of the materials,

1184781

(3) agree to publish or report the significant results of investigations (these reporting requirements are not applied so as to interfere with an opportunity to obtain patent protection for inventions or discoveries), and (4) keep accurate records of the receipt, storage, use, transfer or disposal of materials.

This has become one of the Commission's important programs in "assisting and fostering private research and development to encourage maximum scientific progress."

B. Importance of the Program

The extent and rapid growth of the program is pointed up by the Commission's Fourth Semiannual Report to the Congress. The following outline accents the importance of isotope distribution to the national welfare:

1. Science - diverse researches in all laboratory sciences from agronomy to zoology.

2. Health - direct therapeutic applications, increase in knowledge in physiology, medical science, pharmaceutical action, nutrition and hygiene,

3. Industry - research in metallurgy, chemical reactions, catalysis, measurement, industrial hygiene, etc., and in process control.

4. Agriculture - studies in animal and plant physiology, fertilizer studies.

5. Education - aid in teaching nuclear science and creating interest of future workers in applications of atomic energy.

6. Military - assistance to military research programs and the creation of a reserve of technical workers who become trained in radiation detection and protection.

7. Public appreciation - Public interest in atomic energy progress is greatly accelerated through the success of the isotope distribution program. Immediate results are shown in the cooperation and good will between the public and the AEC, between Project and off-Project scientific and technical personnel and between U. S. and foreign scientists. Much of the Commission's success is judged by the public and scientists at large on its willingness to carry out a wide and liberal policy on the distribution of materials, information and services.

1184782

C. Functions Performed by the Isotopes Division

Within the general policy stated in A (above) the Isotopes Division develops and administers the Commission program. Our activities fall roughly into six main categories: production planning, distribution, utilization, health and safety, advisory service and public relations. An organization chart of the Division and a detailed list of functions is attached.

In three years the number of persons employed in the Division has increased to 43. Our present authorized ceiling is 50, of which 21 are professional grade employees (11 are P-5 or better). This growth has been consistent with the expanding program and is almost in exact agreement with our budget estimates which were based on statistical studies of the applications and inquiries received.

We believe the record of service to the public has been good although introduction of new programs, expansion of services, and ironing out rough spots in procedure have been delayed because of difficulties in recruiting top grade personnel. However, our position in this regard will improve considerably in the next two months and we will be able to provide better service, particularly in industrial research and utilization of isotopes.

D. Increasing Scope of the Program

The scope of operations is Commission-wide, nation-wide and world-wide. The program is continually expanding due to (1) increase in the number of research problems and applications using isotopes (it should be noted that as experience of the users increases the uses are becoming more complex); (2) growth in the number of using institutions of all types (medical, research educational, industrial, Government); (3) spread in geographical distribution of materials to 42 states and 27 foreign countries; (4) growing interest

1184783

and demand for further isotopes, isotopes of particular specifications, and isotope-labeled compound forms; (5) mounting requests for information and assistance on training in isotope techniques, equipment and health protection.

The first announcement concerning radioisotope distribution was made June 1946 and the first shipment made August 2, 1946. Since that time many improvements have been made in production, shipping and availability of new materials (labeled compounds, materials of increased specific activity, etc.). Other major programs have been introduced from time to time, as follows:

Distribution of Boron 10	June 1947
Distribution of D_2 and D_2O	June 1947
Labeled methanol	July 1947
Advisory Field Service Initiated	August 1947
New catalog & price adjustment	September 1947
Foreign Distribution of Radioisotopes	September 1947
Y-12 Stable Isotopes	December 1947
Free Isotopes for Cancer Research	April 1948
Production & Distribution of Labeled Compounds by Commercial Firms	July 1948
Distribution of Tritium and He 3	September 1948

Problems presently under consideration of the Isotopes Division are:

Production and Distribution of Co 60 teletherapy units
Distribution of Cyclotron-produced Isotopes
Distribution of Po-Be Sources
Disposal of waste and discard materials
Regulations on the procurement and safe handling of radioisotopes
Price revision
Publication of new catalog
Relations with USPHS and State Health Departments

E. Basic Considerations in Operation of Program

1. Functions of Isotopes Division may be viewed as being in two somewhat conflictory categories:

a. Control of Distribution

(1) Screening of requests - allocations
(2) Records of use, transfer, disposal, etc.
(3) Legal protection - formulation of regulations
(4) Public health protection - supervision of regulations

1184784

b. Promotion of Usage

(1) Encouraging wider isotope usage through talks, exhibits, and public and technical releases.

(2) Maintenance of central files on all techniques of use and all applications of isotopes.

(3) Distribution of informational circulars, reprints, reference lists, etc., on isotopes.

(4) Provision of advisory field service for assistance in undertaking isotope work and for education on health safety aspects.

(5) Provision of specialized training through assistance in laboratory training courses and production of training films on isotope techniques and applications.

2. Balance necessary between control and promotion aspects

a. Tightness in control necessary because of health protection of users and public.

b. Leniency in control desirable so as not to hold back the many benefits that will surely come from isotope uses.

c. Proper promotion requires education and supervision on health safety aspects commensurate with stimulation of increased usage.

d. In any case, some risk is involved to users and to the public health, hence to legal and moral position of AEC and Isotopes Division. Even with best education and supervision some violations of regulations will ensue and some accidents will happen.

3. Control function should be maintained by the Government, at least for immediate future, because:

a. Basic radioactivity induction device (reactor) may remain classified for sometime.

b. Public health could be endangered by reckless uncontrolled competitive distribution.

c. Scale of business foreseeable for next few years is such that all irradiated materials for the program can be made in one or at most two piles--hence truly free competition is not possible in production of irradiated materials. Also in the case of basic products extracted from irradiated materials, such as C 14 from irradiated N 14 or P 32 from irradiated S 32, one small chemical processing unit can supply whole demand. Since free competition not immediately possible on irradiated materials and basic products, it is in the public interest for this monopoly to remain with the Government.

1184785

4. Vigorous participation in the promotion aspects is both possible and desirable by the Government because:

   a. The Government owns reactors and processing facilities which it must necessarily operate in the conduct of its own researches and developments in atomic energy, thus some of the costs which a commercial operator would need to recover in producing irradiated materials and basic products are already necessarily incurred by the Government irrespective of the isotopes distribution program. To a certain extent therefore production of both radioactive and stable isotopes is a byproduct of essential Commission activities. Production costs are thus inherently low under the Government.

   b. The Government can go further than above and even distribute the irradiated materials and basic products at less than the already inherently low production costs. This is because of the expectation of great returns to the general national health and welfare from the wide scale use of the materials in medicine, science, agriculture and industry. Although the cost to the Government of the isotope distribution program is not over one million dollars a year each for radioactive and stable isotopes, the benefits resulting from this investment, through all the investigations and applications made possible by the program, could in not too many years hence easily be worth 10 to 100 times the original investment.

   c. The Government's participation can take place in areas of enterprise not readily financed or supervised by industry. This includes not only a and b above, but also the provision of intensive and specialized training in isotope usage, such as training schools and training films.

   d. Such promotion of isotope usage by the Government not only does not interfere with private enterprise but actually encourages new areas of enterprise for industry as well as profitable improvements in existing industry. In spite of Government's control function, the promotional aspects have developed free competitional opportunities in the following areas of enterprise:

      (1) Manufacture of measuring and monitoring instruments
      (2) Manufacture of special handling and processing equipment
      (3) Modification of basic products and synthesis of labeled compounds
      (4) Analytical research and development services
      (5) Consultation services
      (6) Manufacture and servicing of devices whose function depends on radioactivity

5. All the control functions are best exercised by one agency:

   a. Screening of request and making of allocations is basically tied to the functions of supervision, policy, inspection, maintenance of records, etc.

   b. Sharing of control function would result in duplicity of records and possible conflict in operation of policies.

c. Although a National Science Foundation or the U. S. Public Health Service could perform this entire function, the AEC is the logical and best equipped agency for this at present, and it is the one provided for doing it under Government law, the Atomic Energy Act.

6. Promotion functions may be shared with many groups, decentralized, etc., however, one agency (the one acting as control agency) should maintain general supervision and coordination, because:

a. Promotion of usage should not be inconsistent with the necessary controls and desirable policies on manner of distribution and use.

b. Promotion of usage should not be inconsistent with ability to deliver materials both as to amounts and specifications.

c. Other groups and agencies have other primary functions and interests, hence in general they will not concentrate on and be aware of all the manifold aspects involved in the total program, as will the central agency.

7. The Isotopes Division is somewhat different from other AEC Divisions in function, because:

a. In addition to certain staff and supervisional functions, it has a rather large operational function. That is, its staff is almost entirely engaged in other functions than supervision of the operations of the Commission or its contractors. Its functions are mainly those connected with services rendered to groups outside the Commission or its direct contractors. In these operational functions the Division must have a staff which can keep up with the outside demands.

b. In requests for isotopes, isotope users often make disclosures of their manner of use of the materials which they do not wish to make known to competitors, either professional or commercial, until they are prepared to patent and/or publish their work. For this reason it would probably not be desirable to transfer the control function to a contractor.

c. Although performing AEC-wide functions and generation of certain staff policy, the Division is a part of Oak Ridge Operations.

F. Questions for Discussion

1. Future scope of the program

a. Should the radioisotope program be prosecuted more vigorously?

b. Should the emphasis on the stable isotope program be revised upward or downward?

c. What should the degree of subsidy of isotope distribution be for

(1) cancer research?
(2) all domestic research uses?
(3) foreign cancer and other research?
(4) commercial and industrial use?

1184787

2. Transfer of Functions

a. Should greater use be made of other Government agencies (USFES for example)?

b. Is the present distribution of functions between the AEC and contractors sound?

3. Degree of control over applications and use

a. Should there be any immediate change in present procedures? In the future? Consider the following:

(1) legal restrictions
(2) manner of use
(3) inspections
(4) reports
(5) patents

4. Advisory Field Service and assistance in training and education

a. Should present health-safety controls be more strict? More liberal?

b. Is the Advisory Field Service function adequate?

c. Is the present radioisotope school adequate with facilities for approximately 300 individuals per year? Should facilities be enlarged to provide classes for persons on a lower technical level?

d. What type of training should be provided for insurance inspectors, public health people, sanitary engineers, etc.?

e. Is it desirable to provide Isotopes Division employees with opportunities to work in laboratories to obtain actual experience with isotopes? What limitations?

5. Organization and operation of the Isotopes Division

a. Is it desirable to continue the office of the Isotopes Division as a part of the ORO?

b. Is the relationship between OR as isotope headquarters and other AEC installations satisfactory?

c. Should an "area office" concept be adopted?

d. Should greater use be made of reactors other than at Oak Ridge? Will Hanford facilities be more easily available?

e. Should the role of the Advisory Committee on Isotope Distribution be continued? Increased? Regionalized?

1184788

EXAMPLES OF AGENCIES WHICH RELY ON THE ISOTOPES DIVISION FOR TECHNICAL ASSISTANCE AND INFORMATION

1. Federal Agencies

   a. U. S. Department of Agriculture
   b. National Bureau of Standards
   c. U. S. Public Health Service
   d. Veterans Administration
   e. Office of Education
   f. National Military Establishment
      (1) Office of Naval Research
      (2) Chemical Warfare Service
      (3) Army Medical Center
      (4) Naval Medical Center
      (5) Naval Radiation Laboratory
      (6) Special Weapons Project

2. State Health Authorities

   a. Medical
   b. Sanitary Engineers
   c. Water Works Engineers
   d. Sewage Disposal Engineers
   e. County
   f. Municipal

3. Associations of Insurance Underwriters

4. Public and Private Carriers

   a. Airlines
   b. Express
   c. Truck
   d. Private vehicles

5. National Committees

   a. National Committee on Radiation Protection

      (1) Subcommittee on Safe Use of Radioisotopes

      (2) Subcommittee on Waste Disposal and Decontamination

1184789

FUNCTIONS PERFORMED BY ISOTOPES DIVISION

1. Recommend policies on isotope distribution (both radioactive and stable isotopes).

2. Receive all applications and issue authorizations for procurement.

3. Survey isotope needs to provide program planning.

4. Follow production situation and maintain inventories.

5. Follow research and development in both production and uses of isotopes (also labeled-compounds).

6. Maintain records on distribution and uses being made of AEC-distributed isotopes.

7. Maintain reference files on all isotope uses and techniques.

8. Provide information requested by large number of correspondents on matters of availability, distribution and use.

9. Assist in preparation of special reports on program.

10. Aid in public relations matters related to the program--a result of increasing interest shown by technical as well as nontechnical societies, groups, and publications.

11. Keep informed on health-protection aspects of isotope program, and within limitations of present authority offer aid to applicants.

12. Assist in setting up shipping regulations--work with committees advising ICC and CAB.

13. Assist in program for establishing standards of radioactivity measurement-work with committee advising National Bureau of Standards.

14. Maintain liaison with numerous off-Commission groups interested in various phases of isotope program--National Research Council, Committee on Growth, National Committee on Radiation Protection, Radiological Society, and others.

15. Provide advisory field service--to supplement correspondence in ascertaining suitability of facilities for health-protection of applicants, and in providing information on availability and uses of isotopes.

16. Maintain liaison with Canadian program for isotope distribution coordination of policies, production and distribution.

17. Handle foreign distribution of isotopes.

18. Handle problems and services concerned with stable isotope distribution.

19. Further the actual use of isotopes in industrial and commercial applications.

1184790

THE ATOMIC ENERGY COMMISSION'S ISOTOPES DISTRIBUTION PROGRAM

Summary of a Special Staff Conference
March 4, 1949 - Washington, D. C.

List of persons attending the conference:

Washington Staff

Carroll L. Wilson, General Manager
Walter J. Williams, Director, Division of Production
Kenneth C. Pitzer, Director, Division of Research
Ralph P. Johnson, Deputy Director, Division of Research
Spofford G. English, Chief, Chemistry Branch, Division of Research
Shields Warren, Director, Division of Biology and Medicine
John Z. Bowers, Deputy Director, Division of Biology and Medicine

Oak Ridge Staff

John C. Franklin, Manager, ORC
Paul C. Aebersold, Chief, Isotopes Division
Nathan H. Woodruff, Assistant Chief, Isotopes Division
T. R. Jones, Administrative Officer, Isotopes Division

NOTE: Prior to the meeting each member of the staff was provided with a statement "Present and Future Scope of Isotope Distribution Program" prepared by the Isotopes Division, ORO, as a basis for discussion. A copy is appended to these notes.

I. OPENING REMARKS

John C. Franklin reviewed the purposes of the conference and the reasons for holding it in Washington at this time:

The isotopes distribution program has been in operation for approximately three years. During that time responsibility for its direction changed from the Manhattan Project to the Commission. Problems concerning policy and operations have been solved individually as they arose with assistance from the Washington Staff when requested. On the whole, isotopes distribution has had less formal direction from Washington than other major programs. The Oak Ridge Staff is pleased with this evidence of confidence.

Although interest in the program has been Commission-wide, this is the first staff discussion of the whole program. It is particularly appropriate now to discuss policies, accomplishments, operations and plans for the future in this field with Dr. Pitzer who, as the new Director of the Division of Research, is responsible for supervision of the isotopes program.

Under the direction of Dr. Aebersold the isotopes program has grown rapidly. Personnel requirements have increased and authorized personnel ceilings have been raised to meet requirements--especially in the higher salary brackets to attract scientists of the ability and experience demanded by the job to be done.

1184791

From the discussion today it is especially desired to receive advice on the money, time and energy to be expended on this program.

Dr. Aebersold reviewed briefly the background material prepared for the meeting. He stated the functions of the Isotopes Division and outlined the operating organization. Special attention was called to the balance which must be maintained between the somewhat conflicting functions of controlling distribution and promoting usage. Dr. Aebersold was appreciative of the assistance of the Commissioners, the General Manager, and the Washington Staff in encouraging wider discussion of the use of isotopes. General public and scientific interest in the program has also been developed through the cooperation of the National Laboratories, the Oak Ridge Institute of Nuclear Studies and many individuals in educational, research and industrial organizations. Technical journals and the press have added impetus to the program by generous allowance of space for reporting developments. Dr. Aebersold concluded with the observation that it has been said that the isotopes program has gone forward rapidly and successfully; however, those in the Isotopes Division can see new ways to expand the uses of isotopes and thereby to foster increased scientific and technical progress. Therefore, the question to be answered by this meeting is: Should the program be pushed more vigorously?

Mr. Wilson remarked that he had had the opportunity to read the agenda and that the explanation of responsibilities, program and policy was well set forth. He expressed satisfaction with the accomplishments in isotope distribution and suggested that this was perhaps the reason formal discussion of the program had not been necessary.

He asked that in the discussion which would follow certain questions be borne in mind:

What is the extent of present operations?

In extrapolating the picture one or two years hence, will our business be top heavy with administrative expense?

Where is the plateau, the saturation point of isotope usage--one, two or five years away?

Will what we are now doing in distribution and control be adequate for the future?

Mr. Wilson noted further that, although there will be "regional leads", whatever policy or program is approved centrally should be done throughout the organization. The same distribution policies and controls should apply nationally.

Costs of present program

Mr. T. R. Jones presented a summary of the allocated operating costs for production of radioactive and stable isotopes at Oak Ridge:

1184792

Radioisotopes. In a cost study submitted January 27, 1949, the Oak Ridge National Laboratory (Carbide and Carbon Chemicals Corporation) production cost compared with income as follows (rate per year):

Production cost	$ 640,504
Income	494,064
Net cost	$ 146,440

Selling prices have been approved on the basis of estimated production costs excluding (1) costs for amortization of the pile and other major facilities, and (2) research and development costs. Development costs stated in the ORNL survey amounted to $229,786 and if included above would increase the net cost to $376,226. Production costs include: 16% for labor, materials, supplies, supervision, etc.; 30% for pile operating charges; and 54% for overhead, steam, power, etc. About 38% of the pile operating expenses are charged to the isotope production program. (Pile operating expense would remain essentially the same whether or not there was any isotope production.)

Stable isotopes. Electromagnetically-concentrated stable isotopes are not produced for direct sale. The Y-12 production of stable isotopes is for the purpose of building a "bank" of all separable stable isotopes from which materials may be withdrawn for nuclear research and returned to stock after the investigation has been completed. Samples are loaned at a charge of $50 each for a period of time agreed on between the applicant and the Isotopes Division. Costs of stable isotope production are now approximately $1,000,000 per year. The costs are justified solely on the value of materials to research. To charge the applicant full production costs would make research with stable isotopes almost prohibitive.

Cancer research. Radioisotopes distributed free of production costs for cancer research will require an allocation of approximately $300,000 for Fiscal Year 1949 and an estimated $450,000 in 1950.

Other programs. The production of isotope-labeled compounds and the distribution of cyclotron-produced radioisotopes are estimated to cost $100,000 per year for each program. Revenues from sales of both these materials may recover approximately 1/3 of the costs, leaving a net cost of $140,000 for the two programs.

Listed above are the major 1949 programs. Administrative costs of the Isotopes Division are not included. The latter costs are as follows for the period June 30, 1948, to February 28, 1949.

Personnel Services	$ 101,995
Travel	9,500
Supplies and Equipment	2,400
Special Training	22,642
	$ 135,537

1184793

II. DISCUSSION

(No attempt is made to record exact statements or to place items in the precise order discussed. The discussion was informal and, although all items of the agenda were considered before adjournment, it was not felt necessary to follow exactly the pattern of questions suggested.)

General

Dr. Shields Warren was asked to open the discussion. He commented on the completeness of the background material presented and on his general satisfaction with the program and with the Isotopes Division's policies and operations. In his opinion it was important that one central agency continue to be responsible for distribution, promotion and control of radioisotopes; and further, it was essential that such control be centered in a government agency.

Dr. Pitzer concurred in the concept of a central office for action and control. He said that he was reassured by the general comment concerning present procedures and that they appear correct. Dr. Johnson added that the use of other reactors for radioisotope distribution should be centralized--each area should not have an administrative structure duplicating the work of the Isotopes Division.

In answer to a question from Dr. Pitzer, Dr. Aebersold estimated the Oak Ridge reactor could handle the demand for most radioisotopes for at least two years, and probably longer. Use would need to be made of Argonne, Brookhaven and Hanford reactors to supplement ORNL production of certain isotopes. Processing facilities at Oak Ridge to be completed this year will be adequate to supply demands for processed radioisotopes for several years. The most limiting factor production-wise is the lack of availability of a high flux pile for producing high specific activity materials specifically for the isotopes distribution program.

Mr. Wilson stated that production and distribution are entirely separate questions. Production facilities at Oak Ridge should be used fully with other reactors supplementing production. However, distribution should be controlled through a centrally administered system, otherwise the Commission will be in "hot water." It was indicated that there should be no exceptions--the system should apply to institutions participating in or associated with the operation of Commission laboratories on other than a direct contract basis.

Regulatory Agency

Dr. Aebersold introduced the subject of possible future use of the U. S. Public Health Service, State Health Departments, or regulatory agencies other than the AEC to enforce health and safety measures connected with radioisotope utilization. It was noted that this would not abrogate the need for an advisory field service by the AEC to assist radioisotope users initially in setting up health and safety facilities and to maintain liaison with any enforcement agency on latest safety information and policies. Two problems were recognized: (1) The Atomic Energy Act authorizes the Commission to distribute byproduct materials (radioisotopes), to issue regulations governing

1184794

possession and use, and to recall materials which are improperly used. It would appear that the power to regulate distribution (make allocations) and the power to enforce compliance should best be in the same agency. (2) Public health is a national problem but under the jurisdiction of the states. The U. S. Public Health Service is largely a service organization to the state health departments. The states will no doubt insist on jurisdiction in these matters, therefore, the Isotopes Division should cooperate with state health services and inform them of all radioisotope distribution to their state and any special health safety problems connected therewith.

Dr. Warren noted that public health officials do not now have adequately trained personnel available for inspecting radiation hazards. He suggested that the annual assemblies of State Health Officers is the place to start training and to bring about awareness of the problems. Perhaps the USPHS channels should be used and that agency might take the initiative in sponsoring training courses. This meeting cannot settle the matter of state vs. federal responsibilities but the best immediate course would be to cooperate in a general education program for health services, offer assistance in correcting hazardous conditions, but retain distribution control.

Mr. Wilson repeated that there must be a single distribution agency, not just to advise but to be responsible for one set of instructions, uniform policies, one set of regulations; in other words, a unified and consistent operation.

Regulations.

Dr. Aebersold pointed out that to have a basis for enforcement there must first be rules and regulations. The Assistant General Counsel, ORO, and the Isotopes Division are working on such regulations. The most difficult area in which to reach agreement is that of waste disposal. This latter problem, of course, increases each year as the number of shipments and quantities shipped become larger. It is anticipated that eventually the Advisory Field Service Branch will require the services of an expert on waste disposal only.

Education and Training

The question of promoting education and training in isotope techniques was discussed in some detail. Although the Isotopes Division is not responsible for operating the isotope training courses of the Oak Ridge Institute of Nuclear Studies, it was largely instrumental in setting up the training school.

Dr. Aebersold discussed the magnitude of the educational task which is falling on the Isotopes Division. The volume of mail requiring answers to technical questions is increasing rapidly each month. Staff members are further called on and expected to present speeches and papers to a wide variety of audiences from national professional societies to local laymen's groups. The Division receives weekly requests for educational, training and exhibit material from groups sponsoring events which range from industrial fairs, medical society meetings and scientific symposia to high school science clubs.

1184795

Questions concerning isotope distribution, availability, research techniques, training opportunities, waste disposal, safe handling, shielding, standardization, shipping, etc., are asked by insurance companies, transportation companies, health officers, sanitary engineers, medical associations, embalmers, committees and subcommittees of national scientific and technical organizations, educational institutions, industrial firms and all large Government groups of prospective users. Because the Isotopes Division is the Commission's announced agency for accepting applications and approving the allocation of isotopic materials, the burden of answering inquiries relating to these matters falls largely on the Isotopes Division and particularly on two Branches of the Division.

The Radioisotopes Branch must be prepared to answer questions of methodology in many fields of radioisotope utilization and to evaluate correctly the feasibility of a proposed application and the ability of the applicant to meet health safety requirements. The Advisory Field Service Branch must answer a large volume of mail concerning radiation protection, monitoring and measuring equipment, laboratory design and handling equipment, disposal, radioactive standards and other technical problems and still find time to make field visits with users to determine that radioactive materials are being used safely and in accordance with purposes and procedures stated in the applications. Allocations are made in most cases on the basis of the application form without a prior field visit to check on adequacy of instrumentation and facilities. During the calendar year personnel of this Branch can visit only 25%, or less, of the current number of radioisotope users. (At this point, Dr. Warren commented that in periodic examination of hospitals it was found practical to make inspections approximately every four years except in special cases and that the Isotopes Division could reasonably follow a similar policy.)

The volume of correspondence shows the tremendous interest in peacetime use of atomic energy, an interest that could develop into many practical applications in medicine, agriculture and industry. The policy of the Division is to answer all correspondence as promptly and accurately as possible, to accept speaking engagements with national scientific and technical societies and other large groups with practical problems, to prepare and distribute special technical and informational circulars, and to assist in promoting symposia and special training courses. Progress is being made in developing the wider use of isotopes by this combination of correspondence and limited personal contact through field visits. However, the real need is for additional training programs--a responsibility which the Isotopes Division cannot undertake with its limited staff.

Mr. Wilson suggested that effective training courses for special groups such as government agencies, sanitary engineers, insurance engineers and state health officers would eventually reduce the Commission administrative work connected with isotope distribution. For example, instead of the Isotopes Division providing assistance to all research projects of the Department of Agriculture, which has projects in almost every state, the DA could train an employee or hire an expert to coordinate their research. He could work closely with the Isotopes Division, perhaps even be assigned to Oak Ridge.
Dr. Aebersold said that specific examples of such a plan can be cited: The

1184796

Veterans Administration [illegible] the direction of Dr. George Lyon to review and approve all applications from Veterans Hospitals before submission to the Isotopes Division and also to channel all information between the two agencies. Another example is the Joint Committee on Radiation Hazards of the Association of Casualty Underwriters which receives information directly from the Isotopes Division and makes distribution to member companies. In general, the Division encourages such methods of liaison with large groups or agencies. In fact, each institution receiving isotopes is supposed to have an Isotopes Committee which gives supervision to isotope work within the institution. Even with such liaison agents the general informational and educational activities of the Isotopes Division are necessarily large.

The record of the ORINS training school was reviewed by Dr. Aebersold. Even without a concerted publicity campaign, three times more applications were received than could be accepted. The school is limited by the need for an experienced teaching staff. The Isotopes Division staff assists in each course by providing lecturers on distribution policies and health problems. The school can accept and train approximately 200 students per year for short courses (4 weeks). Students of advanced research rank only can be accepted which means that there is no appreciable reduction in the amount of informational assistance requested from the Isotopes Division. This training is extremely valuable but there is great need also for training courses for special groups such as health officers and sanitary engineers.

Mr. Wilson remarked that certainly many more persons than 200 per year are interested in training and could attend courses if facilities were nearer to larger population centers than Oak Ridge. Fortunately, training is one of the jobs that can be decentralized. It would be of great advantage to make training a part of the program at Brookhaven, Chicago and Berkeley. Dr. Pitzer pointed out that education was the primary reason for setting up Brookhaven. It was agreed that although promotion of training facilities was in the interest of isotopes distribution, actual responsibility for this program was with the Division of Research and the Division of Biology and Medicine. Dr. Warren noted that the primary problem was to obtain instructors--sound pedogogy--research people were generally not satisfactory instructors or not interested in instruction.

Advisory Field Service

Mr. Franklin stated firmly that he was not in favor of a mushrooming administrative organization for isotope distribution, nevertheless the Commission has a large responsibility in maintaining health safety standards in the use of radioisotopes--some group such as the Advisory Field Service Branch has to do the job. Dr. Aebersold explained how the AFS works. It emphasizes education and assistance in health safety rather than policing or inspection. Trips are scheduled to make maximum use of employees' time and reach the largest number of isotope users.

Use of fewer forms, less red tape and complete mimeographed or printed information on the most frequently asked questions helps to cut down the field work of the Division. Application forms are concise but designed to give

1184797

complete information concerning the ability of the user, the proposed problem and the facilities available for safe handling of radioactive materials. Whenever possible correspondence is shortened by the use of special circulars, catalogs, reprints of pertinent scientific articles, current bibliographies and detailed instructions on procedure which are available from the Division.

Institutions having a large number of users are encouraged to set up a local central committee to maintain liaison with the Isotopes Division on policies and health safety practices and to approve applications and supervise health training and monitoring within the institution. This system works successfully at Harvard, Chicago, California and other large universities.

Mr. Wilson asked about advice or consultation service for industry. Dr. Aebersold replied that information was given to all applicants on availability of materials, feasibility of proposed research and adequacy of health protection measures but that if assistance was needed in accomplishing the work, the firm was referred to a list of available private consultants. Dr. Pitzer mentioned the experience of the University of California in providing consultation service: Individual consultation is provided individual farmer, for instance, but the University avoids duplicating the services offered by industrial consultants. Of course, in some instances such as use of unique instruments which are available only at the University, requests for service are accepted from private industry but the applicant is charged full cost of the service. Mr. Wilson agreed that the extent of detailed consultation service to be offered industrial users is a problem but that the Commission should stay out of this field as much as possible--let private industry do it. There was general agreement on this point with the understanding that it is not always possible to draw a firm line between fundamental research and industrial research and between general advice and detailed consultation. The Isotopes Division should continue to use its judgement on the extent of advisory field service offered to industry concerning the feasibility of proposed work or how to perform work properly and safely.

Industrial uses.

In introducing the subject of radioisotope utilization in industry, Dr. Aebersold first noted that the problem of training was even more acute in this field than in medical and institutional research. The Isotopes Division can see no short cut to alleviation of the problem. Industry has been slow in utilizing radioisotopes in research, in process control and in new products. Tracerlab of Boston has been actively engaged in promoting the "radioisotope industry" and has proposed commercial installations of a thickness gauge--the first application of radioisotopes to industrial process control. The Isotopes Division has authorized two initial installations with the understanding that further distribution will depend on a favorable report by its Advisory Field Service Branch on the safety of the device under actual working conditions. It is proposed to follow this policy in considering other industrial and commercial uses. In special cases, involving field use or possible large-scale public or industrial hygiene hazard, the applications will be referred to the Committee on Isotope Distribution for approval prior to allocation of materials.

1184798

Industrial uses will not increase rapidly until it can be demonstrated that the over-all costs of procurement, shielding, instrumentation, and special handling will permit economic advantage to the user. Applications for industrial use of radioisotopes have not been approved when there has been question of the adequacy of facilities or experience of personnel in the use of radioactive materials. There was little comment on this item except that Isotopes Division procedures met with general approval. Mr. Wilson remarked that he agreed commercial users should be encouraged but approved only on the basis of competence. Industrial use of isotopes could only grow at a rate commensurate with the training of personnel in industry and with the use of safe industrial hygiene and public health practices. It was noted that the Isotopes Division urges commercial and industrial firms to employ consultants to solve their technical problems in the use of radioisotopes rather than rely on the Isotopes Division for such assistance.

Health-Safety Procedure and Controls.

Mr. Franklin asked for opinions concerning the adequacy of health and safety controls presently in use. Dr. Warren said that the record is good, that no instance of grief has been reported. As the program grows our knowledge is increasing as to the precautions necessary. The practical judgement of the Subcommittee on Human Applications should continue to be accepted. It is believed that decisions of the Subcommittee have not hampered worthwhile research. Mr. Wilson remarked that to a considerable extent the judgement of responsible users of radioisotopes must be relied on. No guarantee can be made, however, against accident even with detailed instructions and elaborate handbooks. Certain calculated risks of health hazard are involved and the Commission understands this in furthering the program. The promotion of usage in industry, for example, should not be so rapid as to encourage risks beyond present health-safety experience. It was agreed that the cumulative record is favorable and that the measure of control is adequate.

Concluding Remarks.

It was pointed out by Dr. Aebersold that the Isotopes Division could more actively promote new areas of greater usage and could increase its efforts in the distribution of isotopes. Although an excellent job is being accomplished by the present staff, much extra effort and unpaid overtime is expended. To put more effort in the program it would be necessary to increase the Division's personnel ceiling. On the other hand, Dr. Aebersold recognized that a larger staff is already required to carry out the allocation and control functions of the Division and its associated informational responsibilities, than is actually required in radioisotope production activities at ORNL. It is important, however, to note that personnel requirements will increase with just the normal growth of the program. To accelerate the program would require immediate employment of additional personnel of high professional quality and ability.

1184799

III. CONCLUSIONS

1. The Manager of Oak Ridge Operations and members of the Isotopes Division Staff reviewed fully for the first time with members of the Washington Staff the progress, policies, problems and future of the isotopes distribution program in the light of the first three year's experience. The main objective was to determine whether the over-all progress and general policies are satisfactory. The Isotopes Division indicated wherein it could undertake more rapid promotion of isotope utilization should this be deemed desirable.

2. The Washington Staff members present unanimously felt that the isotopes distribution program is being prosecuted vigorously and properly. The growth of the program was commended and the record was considered one which would be envied by an industrial organization. (It was not suspected until this meeting that in promoting the use of isotopes Dr. Aebersold thought he might be "going up hill, in low gear, with the brakes on and foot dragging.")

3. The rate of growth of the Isotopes Division and the present degree of promotion of isotope utilization is adequate. Steady, sound growth in the future is to be expected. Evidence was presented to show that as the program has grown, the Isotopes Division has endeavored to keep to a minimum the administrative work connected with the program consistent with proper and safe isotope utilization. It was recognized, however, that the steady growth of the program, and especially unpredictable future large-scale uses of isotopes, may require additional personnel. Personnel will not be added expressly for the purpose of promoting an increase in extent of isotope utilization or for providing detailed consultation to industrial users.

4. Oak Ridge is to remain the Commission's center of isotope production and distribution and its facilities should be used to the fullest extent. A limited amount of production and distribution will take place at Argonne and Brookhaven National Laboratories but not of materials that are feasible to obtain from Oak Ridge. To supplement Oak Ridge reactor capacity, materials may be irradiated at other reactors than Oak Ridge and shipped to Oak Ridge to be processed and distributed. The Isotopes Division will continue to function for the AEC as a whole to insure uniform policy and control in the distribution of isotopes and there should be no other option. The Division should prepare a GM Bulletin to be issued from Washington stating procedures to be followed by all offices in the distribution of isotopic materials and irradiation services.

5. Health safety policies and procedures presently exercised under the program are satisfactory. Visits by representatives of the Advisory Field Service Branch to approximately 25% of the total number of users each year will be adequate. Regulations governing the possession and use of radioactive materials should be prepared for publication in the Federal Register as soon as agreement can be reached on technical points. The Committee on Isotope Distribution and its Subcommittees are giving invaluable assistance to the Commission in this program.

1184800

6. Additional training facilities should be provided to encourage research with radioisotopes and to educate officials concerned with public health aspects of isotope utilization. This program, however, is not the primary responsibility of the Isotopes Division. The Washington Division of Research and the Division of Biology and Medicine will promote general training courses for all fields of science and specialized courses for limited groups such as state health officers, insurance inspectors, etc.

7. The organization of the Isotopes Division and its relationships with other AEC offices and with contractors are considered satisfactory. No changes were recommended.

1184801

APR 1 1954

OFFICIAL USE ONLY

ATOMIC ENERGY COMMISSION

AMENDMENTS TO RADIOISOTOPE DISTRIBUTION REGULATIONS

Report by the Manager of Oak Ridge Operations

THE PROBLEM

1. To consider amendment of the Commission's radioisotope distribution regulations concerning quantities of radioisotopes not subject to AEC's licensing procedure, i.e., amounts which may be transferred without the necessity of the transferee obtaining an Authorization for Radioisotope Procurement from the A.E.C.

SUMMARY

2. Current radioisotope distribution regulations provide that radioisotopes distributed by or through the AEC may be transferred only to persons holding an Authorization for Radioisotope Procurement, except as otherwise permitted. For example, an authorization is not required in the case of certain small quantities of radiomaterials specifically exempted from the authorization procedure. The uses and values of small quantities of radioisotopes have increased considerably in the past two years. At the same time, more information has been obtained as to the biological hazards of the radioisotopes. Therefore, it has appeared necessary to review situations in connection with authorization-exempt quantities of radioisotopes. The proposed amendments would alter the amounts of these materials exempt from the authorization procedure bringing the quantities more in line with their relative potential biological hazards as discussed in Appendix "C".

1184802

In many cases, including widely useful isotopes, the new values would be substantially increased above present values.

STAFF JUDGMENTS

3.

RECOMMENDATION

4. That the Atomic Energy Commission:

a. Approve publication in the Federal Register of the amendments to the radioisotope distribution regulation substantially in the form set forth in Appendix "B";

b. Note that the General Manager will arrange for such publication in conformity with the procedure which allows for a thirty-day period after initial publication for receipt of public comments or objections;

c. Note that, if after the thirty-day period no substantial changes are indicated, the General Manager will arrange for publication of the amendments in final form. If substantial changes are indicated, they will be submitted to the Commission for approval; and

d. Note that the Joint Committee on Atomic Energy will be informed of these actions by appropriate letter.

1184803

LIST OF ENCLOSURES

APPENDIX "A"

Background and Discussion

APPENDIX "B"

Proposed Amendment of Part 30 -- Radioisotope Distribution (10 CFR 30)

Annex "A" to Appendix "B"

Letters Regarding Exempt Quantities of Carbon 14 and Tritium

APPENDIX "C"

Justification of Values for Proposed Authorization-Exempt Quantities

1184804

APPENDIX "A"

BACKGROUND AND DISCUSSION

BACKGROUND

1. Regulations governing the possession, use, transfer, and disposal of radioisotopes were published in the Federal Register (16 F. R. 3251, April 13, 1951) and are codified in 10 CFR 30. Amendments to these regulations were published in the Federal Register on July 25, 1953, and January 14, 1954. The regulations specify that radioisotopes produced in AEC facilities or distributed by or through the AEC may not be transferred to another person unless the transferee, in accordance with these regulations, has applied for and received an Authorization for Radioisotope Procurement issued by the AEC. Section 30.13(a) of the regulation provides, however, that the quantities of radioisotopes listed in section 30.71 (Schedule B) are exempt from the authorization procedure. Such exempt quantities may not be combined or altered so as to increase the rate of radiation exposure above the original rate and may not be administered to a human being for any purpose.

2. Present authorization-exempt quantities are: not more than one microcurie of beta and gamma emitters with half-lives greater than 30 days and ten microcuries of beta and gamma emitters with half-lives no greater than 30 days. There are no exempt quantities of alpha emitters. In response to inquiries from suppliers of exempt quantities section 30.13(a) has been construed as follows:

a. There is no limitation on the number of authorization-exempt quantities or items a person may possess;

b. Each sale and shipment must be limited to one exempt quantity or item;

c. The transferee of an exempt quantity must retain the exempt quantities or items in separate containers and may not combine them;

d. Injection of an animal with more than one exempt quantity or item would be "combining" the radioisotope.

DISCUSSION

3. Development of more sensitive instrumentation and techniques has made feasible many experiments and other uses involving minimal quantities which were of little practical utility at the time exempt quantities were originally established. The use of small quantities of radioisotopes for classroom demonstrations at a high school and university level has increased appreciably. Carbon 14 and tritium, for example, are of considerable value as research tools and may be used effectively in relatively small quantities per application or experiment. Frequently, collaborating laboratories desire to exchange small amounts of Carbon 14 or other isotope-labeled compounds. These transfers often involve only a few microcuries of radioactivity, just over the exempt amounts. Before such transfers can be effected, however, the transferee must obtain an Authorization for Radioisotope Procurement.

4. In view of the increasing use of small quantities of radioactivity, the AEC's Advisory Committee on Isotope Distribution at meeting of

May 18-19, 1953, passed the following motion:

> "The Isotopes Division should consider raising the exempt quantity of C 14 and consider raising the exempt level of other isotopes as their importance dictates."

Pursuant to this recommendation the Isotopes Division has obtained the considered opinions of a number of highly qualified persons in this matter and copies of their views are attached as Annex "A" to Appendix "B". All were in agreement that an increase in the exempt quantity of Carbon 14 and tritium would facilitate and simplify research with these materials. As noted by Dr. Wright H. Langham, Los Alamos Scientific Laboratory:

> "I have on a number of occasions had requests for what I consider extremely small amounts of radioactivity, but I refused to answer these requests because I didn't think the distribution of such small amounts was worth the effort which the present restrictions impose."

5. It is to be noted that the use of these materials will be subject to health-safety standards established by the Commission inasmuch as the "exemption" merely permits procurement and transfer of the specified amounts without obtaining an authorization. Since these materials will

6. A further restriction is added that such exempt quantities are not to be added to any food, beverage, cosmetic, drug, or animal, which may be consumed by or applied to human beings. The Federal Food, Drug, and Cosmetic Act would cover most situations of this nature where interstate shipment is involved. The proposed limitation, however, would safeguard against those situations where the FFD&C Act might not be applicable. Exempt quantities may not be used in any type of toys or novelties.

7. The authorization-exempt quantities of radioisotopes set forth in the proposed amendment will result in freer exchange of small amounts of radiomaterials and materially facilitate and stimulate their use in research and development and as instructive aids. The revised amounts, considered in the light of the additional limitations placed on their use, should prove safe under most conditions which may reasonably be expected. The procurement of relatively small quantities of radioisotopes will be greatly simplified without compromising radiological health-safety. As noted in Appendix "C" present quantities have been reviewed from a biological viewpoint. The values for Strontium 90 and Polonium 210 have been scaled downward by a factor of 10 when not included in a sealed source.

1184808

APPENDIX "B"

PROPOSED AMENDMENT OF PART 30 - RADIOISOTOPE DISTRIBUTION (10 CFR 30)

Notice is hereby given that adoption of the following rules is contemplated. All interested persons who desire to submit comments and suggestions for consideration by the General Manager of the Atomic Energy Commission in connection with the proposed rules shall send them to the General Manager, United States Atomic Energy Commission, Washington 25, D. C., within 30 days after publication of this notice in the Federal Register.

Part 30 of Radioisotope Distribution Regulations (10 CFR 30) is hereby amended by deleting sub-section 30.13(a) and Section 30.71 Schedule B, Exempt Quantities and substituting therefor the following:

30.13 Items and Quantities (a) Sections 30.20 through 30.53, inclusive, do not apply to any item listed in 30.70 (Schedule A) nor to any quantity listed in 30.71 (Schedule B): Provided, however, that the transfer, possession, use, and disposal of such items or quantities shall be subject to the following limitations:

(1) No person shall, except as otherwise permitted by a valid authorization, effect an increase in the radioactivity of said scheduled items or quantities by adding other radioactive materials thereto, by combining the radioisotopes from two or more such items or quantities, or by altering them in any other manner so as to increase thereby the rate of radiation exposure of himself or others above the original rate therefrom;

1184809

(2) No person shall administer externally or internally, or direct the administration of, said scheduled items or quantities to a human being for any purpose, including but not limited to diagnostic, therapeutic, and research purposes, except as otherwise permitted by a valid authorization;

(3) No person shall add, or direct the addition of, said scheduled items or quantities to any food, beverage, cosmetic, drug, or other product which may be consumed by or applied to a human being for any purpose, except as otherwise permitted by a valid authorization;

(4) No person shall include said scheduled items or quantities in any device, instrument, apparatus (including component parts thereof and accessories thereto) intended for use in diagnosis, treatment, or prevention of disease in human beings or other animals, or otherwise intended to affect the structure or any function of the body of human beings or other animals, except as otherwise permitted by a valid authorization;

(5) A durable and clearly visible label shall be affixed to each container of said scheduled items or quantities, such label to include the following words "Caution: Radioactivity. Not for human use."

(6) In transferring said scheduled items or quantities to another person, the transferor shall not include more than one scheduled item or quantity in a shipping container, except as otherwise permitted by a valid authorization;

(7) No person shall include said scheduled items or quantities in any toy or novelty.

30.71 Schedule B: Authorization-exempt quantities (See Section 30.13)

Radioisotope	Not as a Sealed Source (Microcuries)	As a Sealed Source* (Microcuries)
Antimony (Sb 124)	1	10
Arsenic 76 (As 76)	10	10
Arsenic 77 (As 77)	10	10
Barium 140 - Lanthanum 140 (BaLa 140)	1	10
Beryllium 7 (Be 7)	50	50
Cadmium 109 - Silver 109 (CdAg 109)	10	10
Calcium 45 (Ca 45)	10	10
Carbon 14 (C 14)	50	50
Cerium 144 - Praseodymium (CePr 144)	1	10
Cesium 137 - Barium 137 (CsBa 137)	1	10
Chlorine 36 (Cl 36)	1	10
Chromium 51 (Cr 51)	50	50
Cobalt 60 (Co 60)	1	10
Copper 64 (Cu 64)	50	50
Europium 154 (Eu 154)	1	10
Fluorine 18 (F 18)	50	50
Gallium 72 (Ga 72)	10	10
Germanium 71 (Ge 71)	50	50
Gold 198 (Au 198)	10	10
Gold 199 (Au 199)	10	10
Hydrogen 3 (Tritium) (H 3)	250	250
Indium 114 (In 114)	1	10
Iodine 131 (I 131)	10	10
Iridium 192 (Ir 192)	10	10
Iron 55 (Fe 55)	50	50
Iron 59 (Fe 59)	1	10
Lanthanum 140 (La 140)	10	10
Manganese 52 (Mn 52)	1	10
Manganese 56 (Mn 56)	50	50
Molybdenum 99 (Mo 99)	10	10
Nickel 59 (Ni 59)	1	10
Nickel 63 (Ni 63)	1	10
Niobium 95 (Nb 95)	10	10
Palladium 109 (Pd 109)	10	10
Palladium 103 - Rhodium 103 (PdRh 103)	50	50
Phosphorus 32 (P 32)	10	10
Polonium 210 (Po 210)	0.1	1
Potassium 42 (K 42)	10	10
Praseodymium 143 (Pr 143)	10	10
Promethium 147 (Pm 147)	10	10

Radioisotope	Not as a Sealed Source (Microcuries)	As a Sealed Source* (Microcuries)
Rhenium 186 (Re 186)	10	10
Rhodium 105 (Rh 105)	10	10
Rubidium 86 (Rb 86)	10	10
Ruthenium 106 - Rhodium 106 (RuRh 106)	1	10
Samarium 153 (Sm 153)	10	10
Scandium 46 (Sc 46)	1	10
Silver 105 (Ag 105)	1	10
Silver 111 (Ag 111)	10	10
Sodium 22 (Na 22)	10	10
Sodium 24 (Na 24)	10	10
Strontium 89 (Sr 89)	1	10
Strontium 90 - Yttrium 90 (SrY 90)	0.1	1
Sulfur 35 (S 35)	50	50
Tantalum 182 (Ta 182)	10	10
Technetium 96 (Tc 96)	1	10
Technetium 99 (Tc 99)	1	10
Tellurium 127 (Te 127)	10	10
Tellurium 129 (Te 129)	1	10
Thallium 204 (Tl 204)	50	50
Tin 113 (Sn 113)	10	10
Tungsten 185 (W 185)	10	10
Vanadium 48 (V 48)	1	10
Yttrium 90 (Y 90)	1	10
Yttrium 91 (Y 91)	1	10
Zinc (Zn 65)	10	10

*A "sealed source" means a radioactive material that is encased in, and is to be used in, a container in a manner intended to prevent leakage of the radioactive material.

NOTE: The quantities listed in Schedule B are not to be interpreted or considered as having any bearing on the determination of safe permissible levels of personnel exposure or for waste disposal. It is the Commission's intention to publish at a later date and incorporate in this part appropriate health and safety standards.

1184812

C O P Y

ANNEX "A" TO APPENDIX "B"

LETTERS REGARDING EXEMPT QUANTITIES OF CARBON 14 AND TRITIUM

UNIVERSITY OF CALIFORNIA
Los Alamos Scientific Laboratory
(Contract W-7405-ENG-36)
Los Alamos, New Mexico

June 24, 1953

Dr. Paul C. Aebersold
Director, Isotopes Division
U. S. Atomic Energy Commission
Oak Ridge, Tennessee

Dear Paul:

I have no doubt that to increase the exempt amounts of carbon-14 and tritium would simplify greatly the distribution of usable, yet harmless, amounts of these materials. I have on a number of occasions had requests for what I considered extremely small amounts of radioactivity, but I refused to answer these requests because I didn't think the distribution of such small amounts was worth the effort which the present restrictions impose. As long as there is a restriction on whether or not the material is to be administered to humans I would like to recommend that the exempt quantities of carbon-14 and tritium be increased to 100 microcuries each. Please let me know if you would like further elaboration on this recommendation.

Sincerely yours,

/s/ Wright H. Langham

WHL/m

1184813

Laboratories
North Chicago, Illinois

Allied Chemical and Dye Corporation
Central Research Laboratory
Morristown, New Jersey

The Atomic Center (Atomlab)
New York, New York

Battelle Memorial Institute
Columbus, Ohio

C. F. Braun & Company
Alhambra, California

Commercial Solvents Corporation
Terre Haute, Indiana

General Electric Company
Schenectady, N.Y.

Industrial Nucleonics Corporation
Columbus, Ohio

The Kelley-Koett Manufacturing Company
Covington, Kentucky

The Kellex Corporation
New York, N. Y.

Lane-Wells Company
Los Angeles, California

Arthur D. Little, Inc.
Cambridge, Massachusetts

Nuclear Instrument and Chemical Corporation
Chicago, Illinois

Nuclear Measurements Corporation
Indianapolis, Indiana

Nuclear Research and Development, Inc.
Saint Louis, Missouri

Precision Inspection Service
Denton, Texas

Radioactive Products, Inc.
Detroit, Michigan

1184814

Curtis Sampson & Associates
Richland, Washington

Saint John X-Ray Laboratory
Carlton, New Jersey

A. O. Smith Corporation
Milwaukee, Wisconsin

Special Instruments Laboratory, Inc.
Knoxville, Tennessee

Sylvania Electric Products, Inc.
Boston, Massachusetts

Technical Associates
Glendale, California

Tracerlab, Incorporated
Boston, Massachusetts

Tracerlab, Incorporated
Berkeley, California

Technical Operations, Inc.
Boston, Massachusetts

U. S. Radium Corporation
New York, N. Y.

U. S. Testing Company, Inc.
Hoboken, New Jersey

X-Ray Engineering Company
San Francisco, California

1184815

AEC, Oak Ridge, Tenn.-6-29-51-50-A3[illegible]

C O P Y

OI:PCA

Oak Ridge, Tennessee
June 18, 1953

Dr. Howard E. Skipper
Assistant Director
Southern Research Institute
Birmingham, Alabama

Subject: INCREASE IN QUANTITIES OF CARBON 14 EXEMPT FROM APPLICATION PROCEDURES

Dear Dr. Skipper:

As you are doubtless aware, at present, quantities of Carbon 14 up to one microcurie in any compound form are exempt from Atomic Energy Commission application procedures for possession and use. The Commission's Advisory Committee on Isotope Distribution, at its 1953 meeting, recommended that consideration be given to increasing the exempt quantity of Carbon 14. Because of the widespread use of Carbon 14 in research, particularly in biology, and to an increasing extent in industry, we agree that serious consideration should be given to raising exempt quantities. Therefore, we are communicating with you to request (1) your opinion concerning the desirability of such a change and, if you concur in the recommendation, (2) the level to which you think the exempt quantity should be raised.

For your information, we are quoting below the Code of Federal Regulations: Radioisotope Distribution, outlining a definition of exempt quantities of radioisotopes and the limitations there are regarding their use:

> Title 10, Part 30, Section 30.71, Schedule B... (b) "Beta and Gamma Emitters: Not more than a combined total of 0.011 millicurie, made up as follows: (1) Half-lives no greater than 30 days: Not more than 0.010 millicurie. (2) Half-lives greater than 30 days: Not more than 0.001 millicurie.... Note: The quantities listed in Schedule B are not to be interpreted or considered as having any bearing on the determination of safe permissible levels of personnel exposure or for waste disposal. It is the Commission's intention to publish at a later date and incorporate in this Part appropriate health and safety standards."

Section 30.13 (Exemptions, Items and Quantities) will shortly be amended to read:

> "Sections 30.20 through 30.53, inclusive, do not apply to any item listed in 30.70 (Schedule A) nor to any quantity listed in 30.71 (Schedule B): Provided, that no person shall, except as otherwise

Annex "A" to
Appendix "B"

1184816

permitted by the regulations contained in this Part, effect an increase in the radioactivity of said scheduled items or quantities by adding other radioactive material thereto, by combining the radioisotopes from two or more such items or quantities, or by altering them in any other manner so as to increase thereby the rate of radiation exposure to himself or others above the original rate therefrom; provided further, that no person shall administer externally or internally, or direct the administration of, said scheduled items or quantities to a human being for any purpose, including but not limited to diagnostic, therapeutic, and research purposes, except as permitted by a valid authorization."

The exemption of beta and gamma ray emitters relieves the user of such quantities from the necessity of filing an application and receiving an authorization. However, it can be seen that exempt quantities can not be administered to human beings nor will they be exempt from such general health and safety standards as the Commission may publish.

Even though administration of exempt quantities to humans is prohibited, we must realize that such quantities might accidentally be ingested; therefore, such quantities should have a maximum limit which would be reasonably safe even under those circumstances. In the case of Carbon 14, this problem is complicated by the fact that body localization and amount of the isotope retained depends upon the chemical compound; for example, in some instances Carbon 14 localizes in chromosomes or becomes incorporated into slow metabolic components. Thus the maximum exempt quantity should represent a reasonably safe amount for the most adverse case of body incorporation. A large sale and traffic is to be expected in exempt quantities of Carbon 14.

We should also like you to consider the exempt quantity of tritium. At present, one microcurie of tritium is also exempt from application procedures, but we should welcome your recommendations concerning the desirability of raising this quantity as well as that for Carbon 14. Inasmuch as interest in tritium may parallel that of Carbon 14, we thought that perhaps the exempt quantities could be increased to the same level. However, we would appreciate your opinions in this regard.

It has been suggested that your opinion would be most helpful. We invite your comments and will appreciate your assistance in these matters. We look forward to hearing from you.

Very truly yours,

/s/ Paul C.Aebersold
Director
Isotopes Division

Annex "A" to
Appendix "B"

1184817

COPY

C O P Y

Southern Research Institute
Birmingham 5, Alabama

July 6, 1953

Dr. Paul C. Aebersold
Director, Isotopes Division
U. S.Atomic Energy Commission
Oak Ridge, Tennessee

Dear Paul:

In reply to your letter of June 18 with regard to increase in quantities of carbon-14 from application procedures the following comments seem to be the consensus of our group.

1. We believe that in view of the widespread use of carbon-14 in biological research that the exempt quantities which might be exchanged between laboratories without authorization should be raised. Most of the published information on the hazards involved in laboratory use of carbon-14 indicate that this isotope (if handled with reasonable care) is not excessively dangerous.

2. The level of exempt quantities which we feel is reasonable is about 50 microcuries. Our experience suggests that there are many experimental situations where collaborating laboratories wish to exchange small amounts of C^{14}-labeled compounds for animal work and the above-mentioned increase would facilitate and simplify such work.

We realize that it will be a long time before any unequivocal statements can be made about hazards with regard to the many available C^{14}-labeled compounds. You mentioned chromosomal incorporation of C^{14}-labeled compounds. Enclosed herewith are photomicrographs of some of our preliminary efforts in this direction.

I would not hold out for the 50 microcurie exempt level; 10-25 microcurie exempt quantities might meet the researchers' needs for freer exchange of C^{14}-labeled compounds. It is obvious that one must balance the desire for freer exchange with the requirement of safety with a material which although the present data are most suggestive we are still not absolutely certain could not be dangerous.

Annex "A" to
Appendix "B"

1184818

With regard to tritium we have done no work on possible hazards. I could make no worth while recommendations on exempt quantities without seeing what data are available on turnover, localization, etc. My guess would be that it might fall in the class with C^{14} in view of its low energy.

I have received your letter of June 29 on suggested changes in the minutes of the fifth meeting of the Advisory Committee. These are satisfactory as far as I am concerned.

With best regards.

Yours sincerely,

/s/ Howard E. Skipper
Assistant Director

hes ed

C O P Y

ARGONNE NATIONAL LABORATORY

P. O. Box 299
Lemont, Illinois

July 8, 1953

Dr. Paul C. Aebersold, Director
Isotopes Division
U. S. Atomic Energy Commission
Oak Ridge, Tennessee

Re your subject: INCREASE IN QUANTITIES OF CARBON 14 EXEMPT FROM APPLICATION PROCEDURES

Dear Paul:

Concerning an increase in the exempt quantities of C 14 and H 3, let me first say that if we look at the problem as one of energy rather than disintegration rate and if we allow 1 μc of Sr 90, we may as well allow 10 μc of C 14 and 100 μc of H 3, whose beta ray energies are, respectively, factors of 10 and 100 below the majority of the beta emitters for which the rule was written. Incidentally, you will recall that the committee on human applications approved the administration of 10 μc C 14 as bicarbonate to certain normal individuals for the express purpose of determining loss, I being one of them.

According to the survey of compounds in ANL-4787 (Conference on C 14 Toxicity) the biological half-life of C 14 is in all cases under thirty days, which might give justification for considering it in Category 1 (half-lives less than thirty days). It can then be objected that a little stays much longer in the body; but this amount must be less than 10% of the amount introduced. On this basis we might be able to permit 100 μc of C 14 and on a similar basis, 1 mc of H 3. Perhaps it would be better at the moment to restrict this to C 14 in the form of carbonate, bicarbonate, or CO_2, and to tritium in the form of HT or water. At the least, I would urge that we use the quantities in the preceding paragraph, and would accept another factor of 10 if others agree and if it seems to accomplish a useful purpose.

Faithfully yours,

/s/ Austin

Austin M. Brues, M.D.
Director-Division of
Biological and Medical Research

AMB/mda

1184820

Annex "A" to
Appendix "B"

C O P Y

C O P Y

GENERAL ELECTRIC COMPANY

Richland, Washington — Hanford Atomic Products Operation

August 14, 1953

Dr. P. C. Aebersold
Director, Isotopes Division
United States Atomic Energy Commission
Oak Ridge, Tennessee

Dear Paul,

INCREASE IN QUANTITIES OF CARBON 14 EXEMPT FROM APPLICATION PROCEDURES

I am sorry to have been so long in replying to your letter dated June 18 on the above subject.

Contrary to the general impression that we are highly conservative at this location, we find that the quantities that we had in mind were higher than those suggested by Dr. Marinelli. Dr. Kornberg had proposals as high as 100 μc for C 14 and 500 μc for tritium. The ratio is determined by the ratio of beta ray energies modified by the relative biological effectiveness of the radiations, which we suspect here to be 2 for tritium although we realize that this does not agree with Dr. Brue's calculations. It appears that these quantities are higher than the ones that will find general acceptance. I do suggest, however, that this ratio of 1 to 5 is better than Dr. Marinelli's ratio of 1 to 10. In your letter to him dated July 1, you have given some additional reasons for further reducing the ratio. I can see no reason why 20 μc of C 14 and 100 μc of tritium should not be reasonable values for exempt quantities. These limits would presuppose reasonably intelligent laboratory management of the material.

I think it would be contrary to the best interests of the nation to hold the limit too low on the basis that such reasonable management is not universally available at this time. The effort should be made to provide the necessary teaching to bring up the standard of control voluntarily.

Sincerely yours,

/s/ Herb

RADIOLOGICAL SCIENCES DEPARTMENT

HM PARKER:EDS

Annex "A" to
Appendix "B"

1184821

C O P Y

C O P Y

OAK RIDGE NATIONAL LABORATORY

CARBIDE AND CARBON CHEMICALS COMPANY

Post Office Box P
Oak Ridge, Tenn.

June 22, 1953

Dr. Paul C. Aebersold
Director
Isotopes Division
U. S. Atomic Energy Commission
Oak Ridge, Tennessee

Dear Paul:

I have your letter of June 18, 1953 in which you ask my opinion relative to an increase in quantities of Carbon 14 and Hydrogen 3 that are to be exempt from application procedures.

I happen to be a member of the National Committee on Radiation Protection and of the committees on shipment of radioisotopes of the National Research Council, both of which are interested in such problems, but any answers that I give to your question will be in the form of personal opinion and will not be intended to reflect any expression of opinion of the above named committees.

I do not know all the implications when one is exempt from "application procedures" except, as you state, the person must still have specific authorization for administering such materials to humans. In any case, I presume it is understood that the applicant is responsible when shipping certain quantities by common carrier to conform to all the shipping regulations established by federal, state, and local agencies. Also, an effort should be made to conform to the recommendations of the National Radiation Protection Committees relative to internal and external exposure and ultimate disposal of the radiation contaminants. Because of the low energy of the radiation emitted by Carbon 14 and Hydrogen 3, these isotopes are considered to be the less hazardous, and the permissible body burden is 250 microcuries of Carbon 14 or 10^4 microcuries of Hydrogen 3. In other words, a person could ingest into his body the present one microcurie level of Carbon 14 or tritium and still retain only a fraction of 1% of the permissible body burden for either of these isotopes. Mrs. Ford and I have prepared a paper in which we made calculations to indicate that in the case of a single intake one would have to ingest about 100 microcuries of Carbon 14 or 1000 microcuries of Hydrogen 3 to deliver an integrated dose of 0.3 reps during

the first week following ingestion, or the person would have to ingest in a single event 2000 microcuries of Carbon 14 or 3000 microcuries of tritium to deliver an integrated dose, 52 x 0.3 = 15.7 reps, during the following year. Therefore, from the standpoint of hazards to persons, I feel the present level of 1 microcurie is exceedingly conservative. As a matter of fact, I believe the limitations should be under the control of contamination from the standpoint of interference with instrumentation rather than hazards to humans. On this basis I would suggest that the value of 10 microcuries seems to be very safe if the person has an understanding of the problems involved and complies with the shipping regulations for the transport of these materials and with the recommendation of the National Committee on Radiation Protection for the use and disposal thereof. I might add at this point that the Harriman Tri-Partite Conference which met during March and April of this year increased the international maximum permissible value for concentration in air from 10^{-6} to 10^{-5} microcuries per cc for Carbon 14 and decreased the maximum permissible value of Hydrogen 3 from 5×10^{-5} microcuries per cc to 2×10^{-5} microcuries per cc.

I hope this is the sort of information you wish, but if I can be of further help please let me know.

Sincerely,

/s/ Karl

Karl Z. Morgan, Director
Health Physics Division

KZM:be

C O P Y

THE UNIVERSITY OF CHICAGO
University Clinics

Argonne Cancer Research Hospital
950 East 59th Street
Chicago 37, Illinois

Office of the Director

July 8, 1953

Dr. Paul C. Aebersold
Director
Isotopes Division
U. S. Atomic Energy Commission
Oak Ridge, Tennessee

Dear Paul:

In re: Carbon 14 Exempt Quantity

I have given your letter careful thought and have sought the advice of a number of my colleagues in the field of research with Carbon 14. In general they all agree with us that a larger exempt quantity should be permitted. The factor of 10 for Carbon 14 seems to be uppermost in everyone's mind, and I'm inclined to believe that this is reasonable since our human use principles still apply.

On tritium, I again agree that we need liberalization, since so many people are getting into research with this element and research will be greatly facilitated by policy liberalization. My own feeling is that the exempt quantity should be increased by no less than a factor of 10, and perhaps one should consider the possibility of a factor of 20 as a more reasonable approach.

Yours sincerely,

/s/ Leon O. Jacobson

Leon O. Jacobson, M.D.

1184824

Annex "A" to
Appendix "B"

C O P Y

APPENDIX "C"

JUSTIFICATION OF VALUES FOR PROPOSED AUTHORIZATION-EXEMPT QUANTITIES

SUMMARY

The proposed authorization-exempt quantities are presented in Table I which is a part of this summary. Data pertaining to factors used in establishing these quantities for each radioisotope are given in Tables 5 and 6 which are located in the text of this Appendix. Factors taken into consideration are internal and external hazards, contamination of laboratory facilities by long-lived materials, utility of the radioisotopes and experience from the radioisotopes distribution program which has been in effect for approximately eight years. The proposed authorization-exempt quantities for sealed sources* are 10 times the non-sealed source quantities for radioisotopes listed in the 0.1 μc and 1.0 μc columns and are the same as the non-sealed source quantities for the remaining radioisotopes. Sealed sources are to conform to the specifications and standards set forth in the proposed Federal Regulations which pertain to sealed sources.

Authorization-exempt quantities will be subject to health safety regulations, labeling, and other regulations pertaining to radioisotopes except that an Authorization For Radioisotope Procurement will not be required. Authorization-exempt quantities may not be used in human beings except as permitted by a valid authorization.

Basic rationale and calculated data for the above factors are presented and evaluated in the text of this Appendix.

*A sealed source is defined as a radioactive material that is encased in, and is to be used in, a container in a manner intended to prevent leakage of the radioactive material.

TABLE I

PROPOSED AUTHORIZATION-EXEMPT QUANTITIES

0.1 μc	1.0 μc	10 μc	50 μc	250 μc
Po 210	Y 90	K 42*	F 18	H 3
Sr-Y 90	Tc 96	Pd 109*	Mn 56	
	Mn 52	Na 24*	Cu 64	
	Ba-La 140	Ga 72*	Ge 71	
	V 48	As 76*	Pd-Rh 103	
	Te 129*	Rh 105*	Cr 51	
	Ag 105*	La 140*	Be 7	
	Fe 59*	As 77*	S 35	
	In 114*	Sm 153*	Tl 204	
	Sr 89*	Au 198*	Fe 55	
	Y 91*	Mo 99*	C 14	
	Sb 124*	Au 199*		
	Sc 46*	Re 186*		
	Ce-Pr 144*	Ag 111*		
	Ru-Rh 106*	I 131*		
	Co 60*	Pr 143*		
	Eu 154*	P 32*		
	Cs-Ba 137*	Rb 86*		
	Ni 63*	Nb 95		
	Tc 99*	Ir 192		
	Ni 59*	Te 127		
	Cl 36*	Ta 182		
		Sn 113		
		W 185		
		Ca 45		
		Zn 65		
		Cd-Ag 109		
		Na 22		
		Pm 147		

*Proposed quantity same as that permitted under present exempt-quantity system.

Note:
Radioisotopes are listed according to half-life within each column.

Authorization-exempt quantities for sealed sources are 10 times the non-sealed source quantities for radioisotopes listed in 0.1 μc and 1.0 μc columns, and are the same as the non-sealed source quantities for the remaining radioisotopes.

The following miscellaneous factors are [illegible]. It is expected that most authorization-exempt radioisotopes will be handled by scientific and educational personnel who will have adequate facilities and training or at least available consultation on radioisotope techniques. For the most part, utility is expected to be well established. Authorization-exempt quantities may be used to a small extent by curiosity-seekers and youthful investigators. The availability and cost of the radioisotopes are expected to restrict use by this type of personnel.

The primary basis for establishing authorization-exempt quantities has been that of limiting the possible exposure to any organ in the body to 300 mrem per week, in the event that one quantity in soluble form might be taken into the body repeatedly once each week. Exceptions to this are the exempt quantities proposed for Sr-Y 90, Po 210, I 131, Ca 45 and Tl 204. For these radioisotopes, with the exception of I 131, repeated weekly intake of the proposed quantity for any of these radioisotopes would exceed MPE to some body organ by a factor of only 2 to 3. This factor for I 131 is 40, which is considered acceptable on the basis of the utility and extensive past experience with this radioisotope. The proposed quantities are not considered to present a significant external radiation hazard although frequent inadvertent contact or near contact exposures could greatly exceed 300 mrem per week.

The primary factor for establishing authorization-exempt quantities, that of limiting internal exposure to MPE for any organ in the body, was chosen because it is considered to be conservative and is the most definite basis available. This is a good basis from which modifications can be made to allow for factors that cannot be numerically evaluated, such as utility, possibility of long-term contamination and the likelihood of a person

ingesting an appreciable quantity of a radioisotope. The probability of a user ingesting or inhaling a major portion of an exempt quantity, week after week, is considered to be very low.

It is believed that most of the quantities could be safely increased severalfold so far as the average user is concerned. Such an increase may be warranted by future findings, such as increased utility and further experience in hazards involved. External exposures would become more significant for larger quantities as would long-term contamination of facilities and public domain, especially for long-lived radioisotopes.

EXPECTED COMPETENCE AND FACILITIES OF USERS

Relatively small quantities of radioisotopes have wide utility in a number of fields as indicated in Table 2. In this table it is noted that the preponderant applications are scientific and educational (which justify the existence of authorization-exempt quantities) rather than applications of questionable nature. This outline also suggests that most prospective users of authorization-exempt quantities have advanced education and facilities which should assure a reasonable degree of health safety.

The expected frequency or continuous use of authorization-exempt quantities are significant in establishing such values. Frequent or continuous use by individuals in the categories of curiosity-seekers is considered to be very unlikely. Those in technical categories may be expected to engage in repeated studies. However, continuous use will not be generally anticipated because: (1) many studies will likely be short-range; (2) long-range studies are likely to lead to the need for quantities exceeding those

TABLE 2

FACTORS OF UTILITY, FACILITIES AND TECHNICAL COMPETENCE
FOR AUTHORIZATION-EXEMPT QUANTITY CONSIDERATIONS

Possible Fields Of Use	Adequacy Of Facilities For Small Scale Tracer Program	Training or Education	Utility - Examples Of Use	Range of Activity Useful in Small Scale Studies
Biology Plant Animal	Usually adequate (probably in university or hospital)	Technical(person probably experienced or consultation available)	Translocation, uptake, autoradiograms,photosynthesis, blood studies, metabolism.	Less than 1 - 25 μc
Physical & Chemical Research	Usually adequate(probably in university or college)	Technical(person probably experienced or consultation available)	Autoradiograms, radiation characteristics, tracer studies, chemical reactions & processes, lubrication, friction, surface transfer of material, fluid flow.	" " 1 - 100 μc
Industrial Research	Usually adequate(probably in industrial research laboratory)	Technical(person probably experienced or consultation available)	Surface transfer of metal, corrosion, lubrication, friction, alloying, mixing, fluid flow, electrical.	" " 1 - 100 μc
Standards	Usually adequate(probably in established radioisotope laboratory)	Technical(probably experienced person)	Calibration, reference sources.	" " 1 - 100 μc
Instruction & Student Participation	Usually adequate(high schools & universities)	Teaching or Technical (experienced personnel provides supervision)	Fundamentals of radioactivity and tracer studies.	" " 1 - 25 μc
Public Demonstration & Exhibits	Usually adequate (preparation probably performed in established radioisotopes laboratory)	Probably technical	Demonstration of radioactivity or products.	" " 1 - 25 μc
Youthful Investigator	Questionable	High school student(with possible advice from teacher)	Education	" " 1 - 10 μc
Curiosity Seeker	Questionable	Unknown. Intentions probably good	Probably none	[illegible]
Crackpot	Questionable	Unknown. Intentions questionable	Probably none	[illegible]

APPENDIX "C"

1184829

proposed for authorization-exempt transfer. From the foregoing considerations it is expected that these quantities will not be used for extended periods of time by any given individual and therefore the associated potential hazards should be minimized. Experience during the past five years with the present exempt quantities has failed to indicate a single case in which hazards have been created by their use.

AVAILABILITY AND COST

In Table 3 considerations are presented on the availability and cost factors of authorization-exempt quantities. These factors, along with costs of suitable instrumentation, should restrict the use of authorization-exempt quantities for the users expected to be the most lacking in training and facilities, i. e., curiosity-seekers and the youthful investigators.

MATERIAL CONTROL AND CONTAMINATION OF FACILITIES

Appreciable contamination of an authorization-exempt quantity user's laboratory is not expected because most users will be engaged in scientific study which cannot be satisfactorily conducted with contaminated facilities. Also their equipment and techniques will most likely be adequate to prevent widespread contamination. However, since contamination presents a potential hazard and is more serious for long half-lived materials, the authorization-exempt quantities for long-lived materials should be less than those for short-lived materials. It is expected that discretion will be exercised in disposal. Even if this is not the case, significant hazards would not be expected from disposal of waste materials by methods normally employed for

TABLE 3

AVAILABILITY OF AUTHORIZATION-EXEMPT QUANTITIES
AND ITS SIGNIFICANCE ON ASSOCIATED HAZARDS

Suppliers	Comments
Primary Suppliers, ORNL, Brookhaven, etc.	Present policy excludes preparation of authorization-exempt quantities except in special cases. Should they set up a distribution program for this level of activity, it is likely that handling costs alone would restrict general usage by the curiosity seeker and the youthful investigator.
Authorized Secondary Suppliers	Present set-ups do not provide for routine authorization-exempt quantities distribution nor has any pricing policy been established. Should demand for these quantities increase to offer a profitable business opportunity, the secondary supplier probably would develop such a distribution system. Although costs of such quantities have never been established, handling and distribution problems would dictate prices high enough to significantly restrict the use by youthful investigators and curiosity seekers.
Authorized radioisotopes users	These will probably be the most common source of supply. In general, it is expected that the authorized user will use discretion as to whom he gives radioisotopes. It seems reasonable to expect that the recipient would usually have technical training, adequate facilities and a source of consultation.
Transfer between unauthorized users	It is expected that unauthorized user (recipient of authorization-exempt quantities) transfer will be primarily between personnel of similar technical levels. Since it is expected that most authorization-exempt quantity users will be technically trained, such transfer probably will not significantly increase the associated hazards so far as this type of user is concerned. Transfers of this type probably will not be great in number because of the limited quantities involved.

similar non-radioactive items. For example, all liquid and soluble wastes could be disposed of in the sewer system. The probability of contamination of the public domain to create a health hazard is considered to be negligible and significant contamination of items with which the public would come in contact would not be expected.

CONTROL

In the use of authorization-exempt quantities, regulations in the Federal Register will provide that: (1) users will comply with AEC radiological health safety regulations, (2) materials being transferred from authorized users or secondary suppliers will be in properly labeled containers, (3) materials will not be used for medical purposes, (4) materials will not be fabricated into products meant for distribution to the general public for medical application, or as toys or novelties, (5) sealed sources will comply with standards for sealed sources.

HEALTH HAZARDS TO PERSONNEL

It appears that facilities and equipment available to users in scientific and educational fields will be adequate to handle and control low microcurie quantities of radioisotopes. The degree of hazard to personnel using authorization-exempt quantities will depend upon their training, work habits, available equipment and type of use. In Table 4 some of the well known factors of internal and external exposure are outlined.

TABLE 4

FACTORS INVOLVED IN RADIATION EXPOSURE TO PERSONNEL

Type of Exposure	Factors Contributing to Exposure	Mode of Intake	Source of Exposure	Control Measures
Internal	Lack of training Inadequate facilities Carelessness Intentional Intake Ignorance of hazards Techniques Accidental Intake	Ingestion	(Contaminated articles such (as hands, food, cigarettes, (etc. (Materials containing radio- (isotopes.	Proper training Proper techniques Adequate facilities Knowledge of hazards Proper personnel attitude
		Inhalation	(Airborne particulates, gases, (mists.	
		Through Skin	(Absorption through skin or (cuts and abrasions in skin.	
External	Lack of training Inadequate facilities Carelessness Intentional exposure Unavoidable exposure Ignorance of hazards Techniques		Unshielded radioisotopes (includes contamination). Scattered radiation. Radiation not absorbed by shielding. Unlabeled radioactive sources.	Proper training Proper techniques Adequate facilities Knowledge of hazards Proper personnel attitude

1184833

The nebulosity and variety of factors involved in the probability of exposure by ingestion or inhalation in specific operations precludes concrete examples. On basis of experience, however, it seems reasonable to conclude that ingestion or inhalation of significant quantities from use of low microcurie amounts of activity are remote even when the most elementary health safety practices are followed. Nevertheless, in considering authorization-exempt quantities the possible hazards from accidental intake of all or large fractions of such quantities must be evaluated.

Internal Exposure

The following factors were considered in appraising hazards associated with internal exposure:

1. Body burden as presented in NBS Handbook 52
2. Weekly intake (single intake once/week) to deliver MPE to any organ
    - A) Ingestion
    - B) Inhalation
        1. soluble
        2. insoluble
3. Single intake (one intake event) to deliver MPE to any organ
    - A) Ingestion
    - B) Inhalation
        1. soluble
        2. insoluble
4. Continuous intake in water and air (NBS Handbook 52)
5. Interrelationship of above items

Maximum permissible single intake values, MPSI, (for single intake event) and maximum permissible weekly intake values, MPWI, (single intake once each week) have been determined on the basis of MPE to either the GI tract, lungs, or critical organ (as listed in NBS Handbook 52). Table A in the annex of this Appendix lists these values by isotope for ingestion and inhalation based on MPE to each of these organs. Table B of the Annex shows continuous weekly intake values determined by using NBS Handbook 52 MPC values for water and air along with MPWI (single intake once/week). These values agree rather closely.

Attention is called to the use of the terms "critical organ" and "limiting organ" in the text of this Appendix. In most instances, "critical organ" is that organ listed in NBS Handbook 52 for each respective radioisotope. For radioisotopes not listed in NBS Handbook 52 "critical organs" as suggested by Dr. K. Z. Morgan's group, Health Physics Division, Oak Ridge National Laboratory, are used. "Limiting organ" is that organ for which the maximum permissible intake, based on MPE to any organ, is the lowest.

Data on Maximum Permissible Single Intake are taken directly from or calculated from equations contained in a prepublication copy of "Developments in Internal Dose Determinations" by Dr. K. Z. Morgan. It is possible that some of the data as presented in the prepublication copy may be changed before final publication. If such changes should occur, three to fourfold variation in the prepublication data would be necessary to significantly affect the proposed authorization-exempt quantities.

The values considered most significant for establishing authorization-exempt quantities have been extracted and are presented in Table 5. Values

TABLE 5

EXCERPT FROM MASTER TABLE[a] ON COMPARISON OF BODY BURDEN WITH MAXIMUM PERMISSIBLE SINGLE AND WEEKLY INTAKE BY INGESTION
(Expressed in Microcuries)

Isotope	Half-Life Physical	Body Burden(b)	MPSI Limiting Organ(c)	MPWI Limiting Organ(d)	MPWI Critical Organ (NBS 52)(e)
F 18	1.87 hr	24	430	430	14000
Mn 56	2.59	2.0	43	43	2500
K 42	12.44	20	14	14	200
Cu 64	12.88	150	100	100	840
Pd 109	13.1	1.5	26	26	200
Ge 72	14.25	8	10	10	560
Na 24	14.9	15	7.3	7.3	170
As 76	26.8	10	11	11	350
Rh 105	36.5	9	27	27	140
La 140	40	24	7.9	7.9	220
As 77	1.67 da	10	15	15	1100
Sm 153	1.95	32	12	12	920
Y 90	2.54	52	3.5	3.5	85
Au 198	2.69	10	18	15	15
Mo 99	2.85	50	19	19	210,000
Au 199	3.3	28	44	36	36
Re 186	3.8	18	15.9	15.9	430
Tc 96	4.3	5	6.2	6.2	440
Mn 52	5.8	2	4	4	32
Ag 111	7.5	36	23	23	5100
I 131	8	0.3	0.47	0.22	0.22
Ce 71	11.4	67	820	820	5800
Ba-La 140	12.8	5	4.3	4.3	10
Pr 143	13.8	29	26	26	120
P 32	14.3	10	12	12	14
V 48	16.0	20	4.5	4.5	160
Pd-Rh 103	17	6.0	110	100	100
Rb 86	19.5	60	11	11	46
Cr 51	26.5	390	720	720	1200
Te 129	32	1.3	5.6	5.6	6.2
Nb 95	35	90	15	15	62
Ag 105	45	18	4.5	4.5	1900
Fe 59	46.3	11	9.5	1.6	1.6
In 114	50	8	3.7	3.7	730
Sr 89	53	2.0	14	3.6	3.6
Be 7	54.5	670	210	210	670
Y 91	57	15	14	6.5	6.5
Sb 124	60	28	4.8	4.8	2600
Ir 192	70	3.4	7.8	7.8	8.4
Sc 46	85	6.0	5.8	5.8	12
S 35	87.1	100	140	94	94
Te 127	90	4.0	24	16	16
Ta 182	111	6.5	7.2	7.2	1800
Sn 113	112	80	24	24	90

TABLE 5

EXCERPT FROM MASTER TABLE [a] ON COMPARISON OF BODY BURDEN WITH MAXIMUM PERMISSIBLE SINGLE AND WEEKLY INTAKE BY INGESTION
(Expressed in Microcuries)

Isotope	Half-Life Physical	Body Burden(b)	MPSI Limiting Organ(c)	MPWI Limiting Organ(d)	MPWI Critical Organ (NBS 52) (e)
Po 210	138.3 da	0.02	0.071	0.033	0.033
W 185	140	70	20	20	1800
Ca 45	152	65	89	5.0	5.0
Zn 65	250	430	23	23	330
Ce-Pr 144	275	5	5.4	1.1	1.1
Cd-Ag 109	330	40	110	11	11
Ru-Rh 106	1 yr	4	5.0	4.	4.3
Na 22	2.6	55	9.4	9.	10
Tl 204	2.7	180	16.7	16.7	100
Pm 147	2.7	120	110	31	31
Fe 55	2.91	1000	840	65	65
Co 60	5.3	3.0	5.0	5.0	150
Eu 154	5.4	22	9.1	0.94	0.94
H 3	12.5	10,000	1300	1300	2400
Sr-Y 90	25	1	7.6	0.039	0.039
Cs-Ba 137	37	90	13	6.4	6.4
Ni 63	85	110	6.1	6.1	660
C 14	5720	250	140	40	40
Tc 99	2.1×10^5	33	47.7	47.7	1200
Ni 59	2 to 3×10^5	39	150	150	2300
Cl 36	4.4×10^5	200	29	29	37

(a) See master table, Table "A", in Annex of this Appendix. Radioisotopes listed in order of half-life.

(b) From NBS Handbook 52 (Soluble materials only).

(c) Maximum Permissible Single Intake, Limiting Organ. The limiting organ is that organ for which the permissible intake is the lowest numerical value for soluble materials. MPSI is that quantity of a radioisotope which will deliver 300 mrem to the limiting organ during the week beginning at the start of the intake period. (Period of intake considered to be not more than 1 day). MPSI values taken directly from or calculated from equations contained in a prepublication copy of Dr. K. Z. Morgan's "Developments in Internal Dose Determinations."

TABLE 5 (continued)
EXCERPT FROM MASTER TABLE[a] OF COMPARISON OF
BODY BURDEN WITH MAXIMUM PERMISSIBLE SINGLE
AND WEEKLY INTAKE BY INGESTION
(Expressed in Microcuries)

(d) Maximum Permissible Weekly Intake, Limiting Organ. MPWI is that quantity of a radioisotope which, if taken internally once each week, will deliver 300 mrem to the limiting organ. (Period of intake considered to be not more than 1 day). Intake by either ingestion or inhalation. Over one-half of instances in which MPWI for the limiting organ and NBS Handbook 52 critical organ are the same, intake is by inhalation. When MPWI, limiting organ and MPSI values are the same, the GI tract is limiting organ.

(e) Maximum Permissible Weekly Intake, Critical Organ (NBS Handbook 52). Lowest value either by ingestion or inhalation (inhalation insoluble not considered). Quantity shown is that which can be taken into the body via lungs or GI tract without exceeding MPE to the NBS 52 critical organ. Exposure to lungs and GI tract not taken into consideration.

listed in this table were selected by evaluating the following factors:

(1) Inhalation of insoluble materials are not considered as significiant as intake of soluble materials and are therefore not listed in this table because:

a) MPSI values are only slightly more limiting than corresponding values for the GI tract (in the order of 0.5 to 0.9 those for GI tract)

b) Only particulates in the order of 0.25 to 5 microns diameter are retained in the lungs

c) Significant number of such particulates would neither be involved nor produced in normal radioisotope use (in fact it is not easy to produce such particles with equipment designed for that purpose)

(2) MPSI, limiting organ, are lowest values based on MPE to any organ for a single intake. (This is usually GI tract which, for soluble materials, is most always one-half the value for the lungs)

(3) MPWI, limiting organ, are lowest values based on MPE to any one organ for repeated weekly intakes (usually established by GI tract, however, for some radio-isotopes MPWI is lowest for MPE to some other organ because of concentration and long effective half-life in that organ.)

(4) MPWI, critical organ, based on permissible weekly intake to deliver MPE to critical organ (NBS Handbook 52) under equilibrium conditions. (Exposure to other organs such as the GI tract not considered.)

(5) Body burden

a) it shows hazard from isotopes deposited in the body

b) it is a value widely used for comparing hazards of deposited materials

c) values have been agreed upon by NCRP

It is to be emphasized that for soluble materials, MPSI values can be repeated weekly when considering exposure to the GI tract and lungs because of the very short effective half-life of radioisotopes in these organs.

External Exposure

In handling authorization-exempt quantities it is reasonably expected that users will normally keep their hands at least 10 cm away from the source and their body a foot away. Also, it is to be noted that:

1. Considerable protection from beta emissions is afforded by their absorption in walls of glassware
2. Time in actual handling of radioactive material is expected to be relatively short
3. The specific activity of the radioactive material in general is expected to be low

Indiscriminate use by irresponsible users or persons not familiar with the hazards could result in local exposure appreciably in excess of MPE.

SELECTION OF SUGGESTED AUTHORIZATION-EXEMPT QUANTITIES

Table 1 presents the amounts for the various radioisotopes which are proposed as authorization-exempt quantities. The primary basis for establishing authorization-exempt quantities is that of limiting the possible exposure to any organ in the body to 300 mrem per week in the event that one quantity, in soluble form, might be taken into the body repeatedly once each week. Other factors considered are external hazards, contamination of laboratory facilities by long-lived materials, utility of radioisotopes and experience from the radioisotopes distribution program. Table 6 shows the most pertinent and decisive factors used in selecting the authorization-exempt quantities for each radioisotope considered.

The proposed exempt quantities for Sr-Y 90, Po 210, Ca 45 and Tl 204 exceed their respective lowest MPSI or MPWI values by a factor of 2 to 3. (Increased because of utility.) The proposed quantity for I 131 is 40 times greater than the MPWI value for the critical organ. This increase for I 131 was based on utility and extensive past experience with this radioisotope.

The primary factor for establishing authorization-exempt quantities, that of limiting internal exposure to MPE for any organ in the body, was chosen because it is considered to be the most definite and conservative basis. This is a good basis from which modifications can be made to allow for factors that cannot be numerically evaluated, such as utility,

TABLE 6

EVALUATION OF FACTORS IN ESTABLISHING
AUTHORIZATION-EXEMPT QUANTITIES FOR SPECIFIC RADIOISOTOPES

Authorization-Exempt Quantity, 0.1 μc

Po 210	Limit set is approximately three times MPSI and MPWI values for limiting and critical organs because of utility.
Sr-Y 90	Limit set at three times MPWI for critical organ because of utility. Quantity could be 7 uc if based on MPSI for limiting organ.

Authorization-Exempt Quantity, 1.0 μc

Y 90	Limit set by MPSI and MPWI for limiting organ. Quantity could be 85 μc if based on MPWI for critical organ.
Tc 96	Limit set by MPSI and MPWI for the limiting organ. Quantity could be 440 μc if based on MPWI for critical organ.
Mn 52	Limit set by MPSI and MPWI for limiting organ. Quantity could be 32 μc if based on MPWI for critical organ.
Ba-La 140	Limit set by MPSI and MPWI for limiting organ. Quantity could be 10 μc if based on MPWI for critical organ.
V 48	Limit set by MPSI and MPWI for limiting organ. Quantity could be 160 μc if based on MPWI for critical organ.
Te 129	Limit set by MPSI and MPWI values for limiting and critical organs.
Ag 105	Limit set by doubling MPSI and MPWI for limiting organ. Quantity could be 1900 μc if based on MPWI for critical organ.
Fe 59	Limit set by MPWI for critical organ. Quantity could be 10 μc if based on MPSI for limiting organ.
In 114	Limit set by MPSI and MPWI for limiting organ. Quantity could be 730 μc if based on MPWI for critical organ.
Sr 89	Limit set by MPWI for critical organ. Quantity could be 14 μc if based on MPSI for limiting organ.
Y 91	Limit set by MPWI for critical organ. Quantity could be 14 μc if based on MPSI for limiting organ.
Sb 124	Limit set by MPSI and MPWI for limiting organ. Quantity could be 2600 μc if based on MPWI for critical organ.
Sc 46	Limit set by MPSI and MPWI for limiting organ. Quantity could be 12 μc if based on MPWI for critical organ.

1184842

TABLE 6 (continued)

EVALUATION OF FACTORS IN ESTABLISHING
AUTHORIZATION-EXEMPT QUANTITIES FOR SPECIFIC RADIOISOTOPES

Authorization-Exempt Quantity, 1.0 μc

Ce-Pr 144 Limit set by MPWI for critical organ. Quantity could be 5 μc if based on MPSI for limiting organ.

Ru-Rh 106 Limit set by MPSI and MPWI for limiting and critical organs.

Co 60 Limit set by MPSI and MPWI for limiting organ. Quantity could be 150 μc if based on MPWI for critical organ.

Eu 154 Limit set by MPWI for critical organ. Quantity could be 10 μc if based on MPSI for limiting organ.

Cs-Ba 137 Limit set by MPWI for critical organ and the possibility of long-term contamination of laboratory facilities. Quantity could be 13 μc if based on MPSI for limiting organ.

Ni 63 Limit set by the possibility of long-term contamination of laboratory facilities and MPWI and MPSI for limiting organ. Quantity could be 660 μc if based on MPWI for critical organ.

Tc 99 Limit set by the possibility of long-term contamination of laboratory facilities. Quantity could be 50 microcuries if based on MPSI and MPWI values for limiting organ and 1200 microcuries if based on MPWI for critical organ.

Ni 59 Limit set by possibility of long-term contamination of laboratory facilities. Quantity could be 150 μc on the basis of MPSI and MPWI values for limiting organ and 2300 μc if based on MPWI for critical organ.

Cl 36 Limit set by the possibility of long-term contamination of laboratory facilities. Quantity could be 30 μc if based on MPSI and MPWI values for limiting and critical organs.

Authorization-Exempt Quantity, 10 μc

K 42 Limit set by MPSI and MPWI for limiting organ. Quantity could be 200 μc if based on MPWI for critical organ.

Pd 109 Limit set by MPSI and MPWI for limiting organ. Quantity could be 200 μc if based on MPWI for critical organ.

Na 24 Limit set by MPSI and MPWI for limiting organ. Quantity could be 170 μc if based on MPWI for critical organ.

Ga 72 Limit set by MPSI and MPWI for limiting organ. Quantity could be 560 μc if based on MPWI for critical organ.

1184843

TABLE 6 (continued)

EVALUATION OF FACTORS IN ESTABLISHING
AUTHORIZATION-EXEMPT QUANTITIES FOR SPECIFIC RADIOISOTOPES

Authorization-Exempt Quantity, 10 μc (cont.)

As 76	Limit set by MPSI and MPWI for limiting organ. Quantity could be 350 μc if based on MPWI for critical organ.
Rh 105	Limit set by MPSI and MPWI for limiting organ. Quantity could be 140 μc if based on MPWI for critical organ.
La 140	Limit set by MPSI and MPWI for limiting organ. Quantity could be 220 μc if based on MPWI for critical organ.
As 77	Limit set by MPSI and MPWI for limiting organ. Quantity could be 1100 μc if based on MPWI for critical organ.
Sm 153	Limit set by MPSI and MPWI for limiting organ. Quantity could be 920 μc if based on MPWI for critical organ.
Au 198	Limit set by and is the same for MPSI and MPWI for limiting organ and MPWI for critical organ.
Mo 99	Limit set by MPSI and MPWI for limiting organ. Quantity could be 210,000 μc if based on MPWI for critical organ.
Au 199	Limit set by and is the same for MPSI and MPWI for limiting organ and MPWI for critical organ.
Re 186	Limit set by MPSI and MPWI for limiting organ. Quantity could be 430 μc if based on MPWI for critical organ.
Ag 111	Limit set by MPSI and MPWI for limiting organ. Quantity could be 5100 μc if based on MPWI for critical organ.
I 131	Limit set on basis of utility and past experience with radioisotopes. Quantity would be 0.22 μc on basis of MPWI for the critical organ and 0.47 μc if based on MPSI for limiting organ.
Pr 143	Limit set by MPSI and MPWI for limiting organ. Quantity could be 120 μc if based on MPWI for critical organ.
P 32	Limit set by and is the same for MPSI and MPWI for limiting organ and MPWI for critical organ.
Rb 86	Limit set by MPSI and MPWI for limiting organ. Quantity could be 46 μc if based on MPWI for critical organ.
Nb 95	Limit set by MPSI and MPWI for limiting organ. Quantity could be 62 μc if based on MPWI for critical organ.

1184844

TABLE 6 (continued)

EVALUATION OF FACTORS IN ESTABLISHING
AUTHORIZATION-EXEMPT QUANTITIES FOR SPECIFIC RADIOISOTOPES

Authorization-Exempt Quantity, 10 μc (cont.)

Ir 192	Limit set by and is the same for MPSI and MPWI for limiting organ and MPWI for critical organ.
Te 127	Limit set by and is the same for MPSI and MPWI for limiting organ and MPWI for critical organ.
Ta 182	Limit set by MPSI and MPWI for limiting organ. Quantity could be 1800 μc if based on MPWI for critical organ.
Sn 113	Limit set by MPSI and MPWI for limiting organ. Quantity could be 90 μc if based on MPWI for critical organ.
W 185	Limit set by MPSI and MPWI for limiting organ. Quantity could be 1800 μc if based on MPWI for critical organ.
Ca 45	Limit set by doubling MPWI for critical organ on basis of utility. Quantity could be 89 μc if based on MPSI for limiting organ.
Zn 65	Limit set by MPSI and MPWI for limiting organ. Quantity could be 330 μc if based on MPWI for critical organ.
Cd-Ag 109	Limit set by MPWI for critical organ. Quantity could be 110 μc if based on MPSI for limiting organ.
Na 22	Limit set by and is the same for MPSI and MPWI for limiting organ and MPWI for critical organ.
Pm 147	Limit set by MPWI for critical organ. Quantity could be 110 μc if based on MPSI for limiting organ.

Authorization-Exempt Quantity, 50 μc

F 18	Limit set at 50 microcuries which is considered as a sufficient quantity of this radioisotope with respect to utility for authorization-exempt use. Quantity could be 430 μc if based on MPSI and MPWI for limiting organ and 14,000 μc if based on MPWI for critical organ.
Mn 56	Limit set by MPSI and MPWI for limiting organ. Quantity could be 2500 μc if based on MPWI for critical organ.
Cu 64	Limit set by MPSI and MPWI for limiting organ. Quantity could be 840 μc if based on MPWI for critical organ.
Ge 71	Limit set at 50 μc which is considered as a sufficient quantity of this radioisotope with respect to utility for authorization-exempt use. Quantity could be 820 μc if based on MPSI and MPWI for limiting organ and 5800 μc if based on MPWI for critical organ.

1184845

TABLE 6 (continued)

EVALUATION OF FACTORS IN ESTABLISHING
AUTHORIZATION-EXEMPT QUANTITIES FOR SPECIFIC RADIOISOTOPES

Authorization-Exempt Quantity, 50 μc (cont.)

Pd-Rh 103 Limit set at 50 μc which is considered as a sufficient quantity of this radioisotope with respect to utility for authorization-exempt use. Quantity could be 100 μc if based on MPSI and MPWI for either the limiting or critical organs.

Cr 51 Limit set at 50 μc which is considered as a sufficient quantity of this radioisotope with respect to utility for authorization-exempt use. Quantity could be 720 μc if based on MPSI and MPWI for the limiting organ and 1200 μc if based on MPWI for the critical organ.

Be 7 Limit set at 50 μc which is considered as a sufficient quantity of this radioisotope with respect to utility for authorization-exempt use. Quantity could be 210 μc if based on MPSI and MPWI for the limiting organ and 670 μc if based on MPWI for the critical organ.

S 35 Limit set at 50 μc which is considered as a sufficient quantity of this radioisotope with respect to utility for authorization-exempt use. Quantity could be 140 μc if based on MPSI for the limiting organ and 94 μc if based on MPWI for the critical organ.

Tl 204 Limit set on basis of utility as a moderate energy beta emitter. Quantity could be 17 μc if based on MPSI and MPWI for limiting organ or 100 μc if based on MPWI for critical organ.

Fe 55 Limit set by MPWI for critical organ. Quantity could be 840 μc if based on MPSI for limiting organ.

C 14 Limit set by MPWI for critical organ. Problem of possible long-term contamination of laboratory facilities considered secondary to utility. Quantity could be 140 μc if based on MPSI for limiting organ.

Authorization-Exempt Quantity, 250 μc

H 3 Limit set at 250 μc which is considered as a sufficient quantity of this radioisotope with respect to utility for authorization-exempt use. Quantity also limited because of possible greater biological effectiveness of very low energy beta and possible localization of some tritiated organic compounds. Quantity could be 1300 μc if based on MPSI and MPWI for limiting organ or 2400 μc if based on MPWI for the critical organ.

possibility of long-term contamination and the likelihood of a person ingesting an appreciable quantity of a radioisotope.

Tables 7 and 8 present estimated dosage rates for beta and gamma radiation from various radioisotopes to aid in evaluating the external hazards from the suggested authorization-exempt quantities. For preparing the data presented in Table 7, it was assumed that the proposed exempt quantity for the respective radioisotope listed, was deposited on an area of 5 sq. cm. of skin. The likelihood of such an occurrence is considered very remote. However, the data obtained serves to illustrate the magnitude of external hazards which might be encountered from beta particles. As might be expected, dosage rates in close proximity to these small quantities are high relative to the MPE value. However, in view of the considerations presented under the section "External Exposure" this is not considered to be a serious hazard. In evaluating long-term contamination, probable chemical and physical forms were considered. For example, although C 14 and H 3 have long half-lives, prolonged contamination has a low probability and is not expected because of exchange and other reactions and their frequent use in the gaseous state. Past experience from field visitation by the Isotopes Division in carrying out the radicisotope distribution program of the U.S.A.E.C. indicates that hazards from investigative uses of low microcurie levels of radioisotopes are insignificant.

It is believed that the authorization-exempt quantities suggested are conservative with respect to radiation hazards to users and could be increased severalfold in most cases so far as personnel safety is concerned.

1184847

TABLE 7

ESTIMATED BETA DOSAGE RATES*
FROM PROPOSED AUTHORIZATION-EXEMPT QUANTITIES

Isotope	$T_{\frac{1}{2}}$	Energy, Mev Beta Max	Dose Rate Rep/hr at 7 mg/cm^2 depth (Exposure Area 5 cm^2)
		0.1 μc Quantities	
Sr-Y 90	25 y	0.61 2.2	0.05
		1 μc Quantities	
Cs-Ba 137	374 y	0.55	0.26
Cl 36	4.4×10^5 y	0.713	0.30
Sr 89	55 d	1.5	0.40
Y 91	57 d	1.53	0.40
Sc 46	85 d	(0.36 (1.49	0.18
Co 60	5.3 y	0.31	0.17
Fe 59	46 d	(0.26 (0.46	0.17
		10 μc Quantities	
Ir 192	70 d	0.67	3.0
Na 24	14.9 h	1.39	3.8
Au 198	2.7 d	0.97	3.2
I 131	8 d	(.33 (.60 (.15 (.81	2.64
Rb 86	195 d	(1.8 (.72	4.00
Nb 95	35 d	.146	0.34
Ca 45	152 d	0.254	1.0
Au 199	3.3 d	0.32	2.1
P 32	14.3 d	1.712	4.0
		50 μc Quantities	
S 35	87 d	0.17	1.7
C 14	5720 y	0.155	1.6
Cu 64	12.9 h	(0.57 (0.65 b +	13.2
		250 μc Quantities	
H 3	12.5 y	0.0189	

Calculated by extrapolating data presented by F. W. Henriques "Effect of Beta Rays" Laboratory Investigation, Vol. 1, No. 2, 1952.

*Gamma radiation not considered.

1184848

TABLE 8

GAMMA DOSAGE RATES* FROM REPRESENTATIVE SUGGESTED AUTHORIZATION-EXEMPT QUANTITIES

Isotope	$T_{\frac{1}{2}}$	Gamma Energy (Mev)	Quantity (μc)	Mr/hr at respective distance				
				1 cm	5 cm	10 cm	30 cm	100 cm
Na 24	14.9h	1.37 2.76	10	223	8.9	2.23	0.24	0.022
Mn 56	2.6h	2.02(20%) 1.77(30%)	50	275	11.0	2.7	0.30	0.03
Co 60	5.3y	1.17 1.33	1	13.8	0.55	0.14	0.01	0.001
Fe 59	46.3d	2.4(50%)	1	6.5	0.26	0.06	0.007	0.0006
Cu 64	12.8h		50	60	2.4	0.60	0.07	0.006
Sc 46	85d	1.12(98%) .89	1	11.4	0.46	0.11	0.01	0.001
As 76	26.8h	.91(94%)	10	51	2.0	0.51	0.05	0.005
Nb 95	35d	.758	10	42	1.70	0.42	0.05	0.0042
K 42	12.4h	1.51(17%)	10	14.2	0.56	0.14	.01	0.001
I 131	8d	.44(99%)	10	28	1.12	0.28	0.03	0.003
Au 198	2.7d	.41	10	24	0.96	0.24	0.03	0.002
Ir 192	70d	.4	10	24	0.96	0.24	0.03	0.002
Rb 86	19.5d	1.1(20%)	10	11.6	0.46	0.116	0.013	0.0012
Ba-La 140	12.8d 40h	.5(40%)	1	1.1	0.04	0.01	0.001	0.0001
Eu 154	5.4y	1.2(90%)	1	5.4	0.22	0.05	0.006	0.0005
Cs 137 Ba 137	33y 2.6m	.66(85%)	1	3.7	0.15	0.04	0.004	0.0004

*Values calculated using R/HR at 1 foot = 6CE

1184849

Radioisotopes whose decay schemes and biological behaviors have not been established are not included in this study.

ANNEX TO APPENDIX C

DISCUSSION OF TABLE A, "COMPARISON OF BODY BURDEN WITH MAXIMUM PERMISSIBLE SINGLE INTAKE AND MAXIMUM PERMISSIBLE WEEKLY INTAKE"

1. "Effective Half-life" from NBS Handbook 52, except Lungs (I), (Lungs insoluble material) which was calculated using a biological half-life of 100 days in the equation

$$T_E = \frac{T_R \times T_B}{T_R + T_B}$$

2. "Critical Organ" is as shown in a prepublication copy of "Developments in Internal Dose Determinations" by Dr. K. Z. Morgan. Organs are listed in ascending order by Maximum Permissible Single Intake.

3. "Body Burden" from NBS Handbook 52 is for soluble material. Value is shown by the same critical organ as that listed in NBS Handbook 52.

"Body Burden" is that quantity of a radioisotope which can be contained by the whole body continuously and will deliver a dose of 0.3 rem/week to the critical organ. The values in NBS Handbook 52 are those for equilibrium conditions associated with continuous daily intake of contaminated air and water.

"Maximum Permissible Single Intake" values are taken directly from or calculated using equations contained in a prepublication copy of Dr. K. Z. Morgan's "Developments in Internal Dose Determinations" and are arranged in ascending order by permissible quantities. These values are based on an exposure of 0.3 rem/week to the critical organ for the week beginning at the start of the intake period. The intake period is short (not more than 1 day) compared to the weekly exposure period. All values are for soluble material except that for "Inhalation, insoluble."

The following equation was used:

$$D = \frac{80\, E\, f\, I_o\, T\, RBE}{n}\left(1-e^{\frac{-0.693\, t}{T}}\right)$$

Where

D = 0.3 rem, dose to the critical organ

E = effective energy (Mev) absorbed in the critical organ per disintegration

I_o = total amount (μc) of radioisotope taken into body by inhalation or ingestion in a single event (for purposes of calculation assumed to be over a period of not more than 1 day)

f = fraction of the radioisotope taken into the body that arrives in the critical organ

T = effective half-life in days

m = mass of critical organ in grams

RBE = relative biological effectiveness factor

t = exposure period = 7 days

5. Maximum Permissible Weekly Intake is that quantity which can be taken in weekly after the initial Maximum Permissible Single Intake and is calculated from Maximum Permissible Single Intake. Weekly intake is equal to that portion of Single Intake which has been eliminated by radioactive decay and biological turnover. This was obtained as follows:

$$MPWI = MPSI \left(1 - e^{\frac{-0.693\ t}{T}}\right)$$

where

t = exposure period = 1 week

and

T = effective half-life of organ under consideration, weeks

6. Chemical form or compound of radioisotope considered for original calculations not known.

COMMENTS

1. MPSI and MPWI are the same for GI Tract and Lungs, Sol. because the effective half-life is so short.

MPWI = 0.999 MPSI for T, eff. = 0.1 week

2. For MPSI the limiting critical organ is the GI Tract except for the following radioisotopes: (Lungs Insol. disregarded).

Au 198	$\frac{\text{MPSI Kidney}}{\text{MPSI G.I. Tract}}$	= 1
I 131	$\frac{\text{MPSI Thyroid}}{\text{MPSI G.I. Tract}}$	= 0.01
Fe 55	$\frac{\text{MPSI Blood}}{\text{MPSI G.I. Tract}}$	= .65

In instances where Lungs, Insol. is the limiting organ its value is (from inspection) on the order of 0.5 to 0.9 for MPSI for G.I. Tract.

1184852

3. For nearly all (except 3) radioisotopes considered, MPSI Lungs, soluble, is 2 times that for MPSI G.I. Tract.

4. MPWI values (for soluble materials) for MPE to G.I. Tract are smallest for 45 of the 65 isotopes listed. Other isotopes are limited by MPE to critical organ (as listed in NBS Handbook 52). These values differ because of (1) fraction of intake reaching critical organ; (2) size of critical organ; (3) effective half-life in critical organ; and (4) type and energy of radiation.

5. By reference to Table B of this annex, it is seen that MPWI values as calculated are in fair agreement with MPWI values based on continuous intake in air and water as presented in NBS Handbook 52.

1184853

COMPARISON OF BODY BURDEN WITH MAXIMUM PERMISSIBLE SINGLE INTAKE AND MAXIMUM PERMISSIBLE WEEKLY INTAKE

Isotope	Half-life Physical	Half-life Effective Weeks	Critical Organ	Mode of Intake	Body Burden, μc	M.P.Single Intake, μc	M.P.Weekly Intake, μc	MPSI / Body Burden	MPWI / Body Burden
F 18	1.87 hr		G.I.Tract	Ingestion		4.3×10^{2}	4.3×10^{2}	18	18
			Lungs	Inhalation(S)		8.7×10^{2}	8.7×10^{2}		
		0.011	Lungs	Inhalation(I)		1.7×10^{3}	1.7×10^{3}		
		0.011	Bone	Ingestion	2.4×10^{1}	1.4×10^{4}	1.4×10^{4}		583
Mn 56	2.59 hr		G.I.Tract	Ingestion		4.3×10^{1}	4.3×10^{1}	22	22
			Lungs	Inhalation(S)		8.6×10^{1}	8.6×10^{1}		
		0.015	Lungs	Inhalation(I)		1.6×10^{2}	1.6×10^{2}		
		.0152	Liver	Inhalation	7.5	5.6×10^{2}	5.6×10^{2}		
		.0152	Kidneys	Ingestion	2.0	2.5×10^{3}	2.5×10^{3}		1250
		.0152	Liver	Ingestion		5.0×10^{3}	5.0×10^{3}		
K 42	12.44 hr		G.I.Tract	Ingestion		1.4×10^{1}	1.4×10^{1}	0.7	0.7
			Lungs	Inhalation(S)		2.8×10^{1}	2.8×10^{1}		
		0.074	Lungs	Inhalation(I)		3.8×10^{1}	3.8×10^{1}		
		.0730	Muscle	Ingestion	2.0×10^{1}	2.0×10^{2}	2.0×10^{2}		10
Cu 64	12.88 hr		G.I.Tract	Ingestion		1.0×10^{2}	1.0×10^{2}	0.67	0.67
			Lungs	Inhalation(S)		2.0×10^{2}	2.0×10^{2}		
		0.0765	Lungs	Inhalation(I)		2.8×10^{2}	2.8×10^{2}		
		0.076	Liver	Inhalation	1.5×10^{2}	8.4×10^{2}	8.4×10^{2}		5.6
		0.0760	Liver	Ingestion		1.2×10^{3}	1.2×10^{3}		
Pd 109	13.1 hr		G.I.Tract	Ingestion		2.6×10^{1}	2.6×10^{1}	17	17
		0.07	Lungs	Inhalation(I)		1.8×10^{2}	1.8×10^{2}		
			Kidneys	Inhalation	1.5	2.0×10^{2}	2.0×10^{2}		133
		0.07	Kidneys	Ingestion		3.5×10^{2}	3.5×10^{2}		
Ga 72	14.25 hr		G.I.Tract	Ingestion		1.0×10^{1}	1.0×10^{1}	1.2	1.2
			Lungs	Inhalation(S)		2.0×10^{1}	2.0×10^{1}		
		0.084	Lungs	Inhalation(I)		2.7×10^{1}	2.7×10^{1}		
		.0842	Bone	Inhalation	8.0	5.6×10^{2}	5.6×10^{2}		70
		.0842	Bone	Ingestion		1.4×10^{5}	1.4×10^{5}		

1184854

COMPARISON OF BODY BURDEN WITH MAXIMUM PERMISSIBLE SINGLE INTAKE AND MAXIMUM PERMISSIBLE WEEKLY INTAKE

Isotope	Half-life Physical	Half-life Effective Weeks	Critical Organ	Mode of Intake	Body Burden, μc	M.P.Single Intake, μc	M.P.Weekly Intake, μc	MPSI / Body Burden	MPWI / Body Burden
Na 24	14.9 hr		G.I.Tract	Ingestion		7.3	7.3	0.49	0.49
			Lungs	Inhalation(S)		1.4×10^{1}	1.4×10^{1}		
		0.087	Lungs	Inhalation(I)		1.9×10^{1}	1.9×10^{1}		
		0.0860	T.Body	Ingestion	1.5×10^{1}	1.7×10^{2}	1.7×10^{2}		11
As 76	26.8 hr		G.I.Tract	Ingestion		1.1×10^{1}	1.1×10^{1}	1.1	1.1
			Lungs	Inhalation(S)		2.2×10^{1}	2.2×10^{1}		
		0.158	Lungs	Inhalation(I)		2.2×10^{2}	2.2×10^{2}		
		0.156	Kidneys	Inhalation	1.0×10^{1}	3.5×10^{3}	3.5×10^{3}		35
		0.156	Kidneys	Ingestion		3.2×10^{3}	3.2×10^{3}		
Rh 105	36.5 hr		G.I.Tract	Ingestion		2.7×10^{1}	2.7×10^{1}	3.0	3.0
		0.214	Lungs	Inhalation(I)		4.6×10^{1}	4.4×10^{1}		
			Lungs	Inhalation(S)		5.3×10^{1}	5.3×10^{1}		
		0.200	Kidneys	Inhalation	9.0	1.4×10^{2}	1.4×10^{2}		16
		0.200	Kidneys	Ingestion		2.5×10^{2}	2.4×10^{2}		
La 140	40 hr		G.I.Tract	Ingestion		7.9	7.9	0.33	0.33
		0.234	Lungs	Inhalation(I)		1.4×10^{1}	1.3×10^{1}		
			Lungs	Inhalation(S)		1.6×10^{2}	1.6×10^{2}		
		0.229	Bone	Inhalation	2.4×10^{1}	2.3×10^{2}	2.2×10^{2}		9.2
		0.229	Bone	Ingestion		1.9×10^{4}	1.8×10^{4}		
As 77	1.67 da		G.I.Tract	Ingestion		1.5×10^{1}	1.5×10^{1}	1.5	1.5
		0.23	Lungs	Inhalation(I)		8.8×10^{1}	8.4×10^{1}		
			Kidneys	Inhalation	10	1.2×10^{3}	1.1×10^{3}		110
		0.23	Kidneys	Ingestion		1.1×10^{4}	1×10^{4}		
Sm 153	1.95 da		G.I.Tract	Ingestion		1.2×10^{1}	1.2×10^{1}	0.37	0.37
		0.28	Lungs	Inhalation(I)		5.4×10^{3}	4.9×10^{2}		
			Bone	Inhalation	32	1×10^{6}	9.2×10^{6}		29
		0.28	Bone	Ingestion		1.8×10^{6}	1.6×10^{6}		

1184855

TABLE A

COMPARISON OF BODY BURDEN WITH MAXIMUM PERMISSIBLE SINGLE INTAKE AND MAXIMUM PERMISSIBLE WEEKLY INTAKE

Isotope	Half-life Physical	Half-life Effective Weeks	Critical Organ	Mode of Intake	Body Burden, µc	M.P.Single Intake, µc	M.P.Weekly Intake, µc	MPSI / Body Burden	MPWI / Body Burden
Y 90	2.54 da		G.I.Tract	Ingestion		3.5	3.5	0.07	0.07
		0.36	Lungs	Inhalation(I)		18.0	15.0		
			Bone	Inhalation		1×10^{2}	8.5×10^{1}		1.6
		0.37	Bone	Ingestion	52	5×10^{4}	4.2×10^{4}		
Au 198	2.69 da	0.362	Kidneys	Inhalation	10	1.8×10^{1}	1.5×10^{1}		1.5
			G.I.Tract	Ingestion		1.8×10^{1}	1.8×10^{1}	1.8	
		0.374	Lungs	Inhalation(I)		2.5×10^{1}	2.1×10^{1}		
			Lungs	Inhalation(S)		3.6×10^{1}	3.6×10^{1}		
		0.362	Kidneys	Ingestion		5.3×10^{1}	4.5×10^{1}		
Mo 99	2.85 da		G.I.Tract	Ingestion		1.9×10^{1}	1.9×10^{1}	0.38	0.38
		0.395	Lungs	Inhalation(I)		2.6×10^{1}	2.2×10^{1}		
			Lungs	Inhalation(S)		3.9×10^{5}	3.9×10^{5}		4200
		0.400	Bone	Ingestion	5.0×10^{1}	2.6×10^{5}	2.1×10^{5}		
Au 199	3.3 da		G.I.Tract	Ingestion		4.4×10^{1}	4.4×10^{1}	1.6	
		0.443	Kidneys	Inhalation	2.8×10^{1}	4.5×10^{1}	3.6×10^{1}		1.3
		0.456	Lungs	Inhalation(I)		5.7×10^{1}	4.5×10^{1}		
			Lungs	Inhalation(S)		8.9×10^{1}	8.9×10^{1}		
		0.443	Kidneys	Ingestion		1.4×10^{2}	1.1×10^{2}		
Re 186	3.8 da		G.I.Tract	Ingestion		15.9	15.9	0.88	0.88
		0.53	Lungs	Inhalation(I)		? $\times 10^{2}$	2.4×10^{-1}		
			Thyroid	Inhalation		4.3×10^{2}	4.3×10^{2}		24
		0.063	Thyroid	Ingestion	18.0	4.3×10^{2}	4.3×10^{2}		
Tc 96	4.3 da		G.I.Tract	Ingestion		6.2	6.2	1.2	1.2
		0.589	Lungs	Inhalation(I)		7.3	5.1		
			Lungs	Inhalation(S)		1.2×10^{1}	1.2×10^{2}		88
		0.300	Kidneys	Ingestion	5.0	4.9×10^{2}	4.4×10^{2}		

1184856

TABLE A

COMPARISON OF BODY BURDEN WITH MAXIMUM PERMISSIBLE SINGLE INTAKE AND MAXIMUM PERMISSIBLE WEEKLY INTAKE

Isotope	Half-life Physical	Half-life Effective Weeks	Critical Organ	Mode of Intake	Body Burden, μc	M.P.Single Intake, μc	M.P.Weekly Intake, μc	MPSI / Body Burden	MPWI / Body Burden
Mn 52	5.8 da		G.I.Tract	Ingestion		4.0	4.0	2.0	2.0
		0.78	Lungs	Inhalation(I)		5.5	3.2		
			Kidneys	Inhalation	2	3.8×10^{1}	3.2×10^{1}		16.0
		0.38	Kidneys	Ingestion		2.1×10^{2}	1.7×10^{2}		
Ag 111	7.5 da		G.I.Tract	Ingestion		2.3×10^{1}	2.3×10^{1}	0.64	0.64
		0.995	Lungs	Inhalation(I)		2.4×10^{1}	1.2×10^{1}		
			Lungs	Inhalation(S)		4.6×10^{1}	4.6×10^{1}		
		0.300	Liver	Inhalation	3.6×10^{1}	5.7×10^{3}	5.1×10^{3}		142
		0.300	Liver	Ingestion		7.6×10^{4}	6.8×10^{4}		
I 131	8 da	1.100	Thyroid	Ingestion	$3. \times 10^{-1}$	4.7×10^{-1}	2.19×10^{-1}		0.73
		1.06	Lungs	Inhalation(I)		2.0×10^{1}	9.6		
			G.I.Tract	Ingestion		4.7×10^{1}	4.7×10^{1}	1.6×10^{2}	
			Lungs	Inhalation(S)		9.4×10^{1}	9.4×10^{1}		
Ge 71	11.4 da	1.46	Lungs	Inhalation(I)		8.1×10^{2}	3.1×10^{2}		
			G.I.Tract	Ingestion		8.2×10^{2}	8.2×10^{2}	12	12
			Lungs	Inhalation(S)		1.6×10^{3}	1.6×10^{3}		
		0.558	Kidneys	Inhalation	6.7×10^{1}	8.1×10^{3}	5.8×10^{3}		86
		0.558	Kidneys	Ingestion		2.0×10^{5}	1.4×10^{5}		
Ba 140 and La 140	12.8 da	1.62	Lungs	Inhalation(I)		4.2	1.5		
			G.I.Tract	Ingestion		4.3	4.3	0.86	
			Lungs	Inhalation(S)		8.6	8.6		
		1.72	Bone	Inhalation	5	3.1×10^{1}	1.0×10^{1}		2.0
		1.72	Bone	Ingestion		8.9×10^{1}	3.0×10^{1}		
Pr 143	13.8 da	1.73	Lungs	Inhalation(I)		2.5×10^{1}	8.4		
			G.I.Tract	Ingestion		2.6×10^{1}	2.6×10^{1}	0.90	0.90
			Lungs	Inhalation(S)		5.4×10^{1}	5.4×10^{1}		
		1.57	Bone	Inhalation	2.9×10^{1}	3.4×10^{2}	1.2×10^{2}		4.1
		1.57	Bone	Ingestion		1.7×10^{4}	6.1×10^{3}		

1184857

TABLE X

COMPARISON OF BODY BURDEN WITH MAXIMUM PERMISSIBLE SINGLE INTAKE AND MAXIMUM PERMISSIBLE WEEKLY INTAKE

Isotope	Half-life Physical	Half-life Effective Weeks	Critical Organ	Mode of Intake	Body Burden, μc	M.P.Single Intake μc	M.P.Weekly Intake μc	MPSI / Body Burden	MPWI / Body Burden
P 32	14.3 da	1.78	Lungs	Inhalation(I)		1.1×10^{1}	3.6	1.2	1.2
			G.I.Tract	Ingestion		1.2×10^{1}	1.2×10^{1}		
			Lungs	Inhalation(S)		2.4×10^{1}	2.4×10^{1}		
		2.00	Bone	Ingestion	1.0×10^{1}	4.7×10^{1}	1.4×10^{1}		1.4
V 48	16.0 da	1.97	Lungs	Inhalation(I)		4.2	1.2	0.22	0.22
			G.I.Tract	Ingestion		4.5	4.5		
			Lungs	Inhalation(S)		8.9	8.9		8.0
		1.72	Bone	Inhalation	2.0×10^{1}	4.9×10^{2}	1.6×10^{2}		
		1.72	Bone	Ingestion		2.4×10^{4}	8.0×10^{3}		
Pd 103 and Rh 103	17 da	2.08	Lungs	Inhalation(I)		1.0×10^{2}	2.8×10^{1}	18	17
			G.I.Tract	Ingestion		1.1×10^{2}	1.1×10^{2}		
		0.63	Kidneys	Inhalation	6.0	1.5×10^{2}	1.0×10^{2}		
			Lungs	Inhalation(S)		2.2×10^{2}	2.2×10^{2}		
		0.63	Kidneys	Ingestion		2.6×10^{2}	1.7×10^{2}		
Rb 86	19.5 da	2.33	Lungs	Inhalation(I)		1.0×10^{1}	2.6	0.18	0.18
			G.I.Tract	Ingestion		1.1×10^{1}	1.1×10^{1}		
			Lungs	Inhalation(S)		2.2×10^{1}	2.2×10^{1}		0.77
		1.11	Muscle	Ingestion	6.0×10^{1}	1.0×10^{2}	4.6×10^{1}		
Cr 51	26.5 da	2.99	Lungs	Inhalation(I)		6.6×10^{2}	1.4×10^{2}	1.8	1.8
			G.I.Tract	Ingestion		7.2×10^{2}	7.2×10^{2}		
			Lungs	Inhalation(S)		1.4×10^{3}	1.4×10^{3}		3.1
		3.14	Kidneys	Inhalation	3.9×10^{2}	6.5×10^{3}	1.2×10^{3}		
		3.14	Kidneys	Ingestion		3.7×10^{4}	7.0×10^{3}		
Te 129	32 da	3.46	Lungs	Inhalation(I)		5.1	9.3×10^{-1}	4.3	4.3
			G.I.Tract	Ingestion		5.6	5.6		
			Lungs	Inhalation(S)		1.1×10^{1}	1.1×10^{1}		4.8
		1.43	Kidneys	Inhalation	1.3	1.6×10^{1}	6.2		
		1.43	Kidneys	Ingestion		4.7×10^{2}	1.8×10^{2}		

1184858

TABLE A

COMPARISON OF BODY BURDEN WITH MAXIMUM PERMISSIBLE SINGLE INTAKE AND MAXIMUM PERMISSIBLE WEEKLY INTAKE

Isotope	Half-life Physical	Half-life Effective	Critical Organ	Mode of Intake	Body Burden, μc	M.P.Single Intake, μc	M.P.Weekly Intake, μc	MPSI / Body Burden	MPWI / Body Burden
Nb 95	35 da	3.70	Lungs	Inhalation(I)		1.4×10^{1}	2.4		
			G.I.Tract	Ingestion		1.5×10^{1}	1.5×10^{1}	0.17	0.17
			Lungs	Inhalation(S)		3.1×10^{1}	3.1×10^{1}		
		3.00	Bone	Ingestion	9.0×10^{1}	3.0×10^{2}	6.2×10^{1}		0.69
Ag 105	45 da	4.43	Lungs	Inhalation(I)		4.1	5.9×10^{-1}		
			G.I.Tract	Ingestion		4.5	4.5	0.25	0.25
			Lungs	Inhalation(S)		9.1	9.1		
		0.400	Liver	Inhalation	1.8×10^{1}	2.3×10^{3}	1.9×10^{3}		106
		0.400	Liver	Ingestion		3.1×10^{4}	2.5×10^{4}		
Fe 59	46.3 da	4.50	Lungs	Inhalation(I)		8.6	1.2		
			G.I.Tract	Ingestion		9.5	9.5	0.86	
		3.96	Blood	Ingestion	1.1×10^{1}	9.8	1.6		0.14
			Lungs	Inhalation(S)		1.9×10^{1}	1.9×10^{1}		
In 114	50 da		G.I.Tract	Ingestion		3.7	3.7	0.46	0.46
		5.0	Lungs	Inhalation(I)		8.5	1.1		
			Spleen	Inhalation					
		3.56	Spleen	Ingestion	8.0	4.3×10^{3}	7.3×10^{2}		91
Sr 89	53 da	4.95	Lungs	Inhalation(I)		1.3×10^{1}	1.7		
			G.I.Tract	Ingestion		1.4×10^{1}	1.4×10^{1}	7.0	
			Lungs	Inhalation(S)		2.8×10^{1}	2.8×10^{1}		1.8
		7.43	Bone	Ingestion	2.0	4.1×10^{1}	3.6		
Se 7	58.5 da	5.03	Lungs	Inhalation(I)		1.9×10^{2}	2.4×10^{2}		
			G.I.Tract	Ingestion		2.1×10^{2}	2.1×10^{2}	0.31	0.31
			Lungs	Inhalation(S)		4.2×10^{2}	4.2×10^{2}		
		6.95	Bone	Inhalation	6.7×10^{2}	7.0×10^{2}	6.7×10^{2}		1.0
		6.95	Bone	Ingestion		1.8×10^{3}	1.7×10^{4}		

1184859

TABLE A

COMPARISON OF BODY BURDEN WITH MAXIMUM PERMISSIBLE SINGLE INTAKE AND MAXIMUM PERMISSIBLE WEEKLY INTAKE

Isotope	Half-life Physical	Half-life Effective Weeks	Critical Organ	Mode of Intake	Body Burden, μc	M.P.Single Intake, μc	M.P.Weekly Intake, μc	MPSI / Body Burden	MPWI / Body Burden
Y 91	57 da	5.18	Lungs	Inhalation(I)		1.2×10^{1}	1.5	0.93	
			G.I.Tract	Ingestion		1.4×10^{1}	1.4×10^{1}		
			Lungs	Inhalation(S)		2.8×10^{1}	2.8×10^{1}		0.43
		7.30	Bone	Inhalation	1.5×10^{1}	7.1×10^{1}	6.5		
		7.30	Bone	Ingestion		3.6×10^{4}	3.3×10^{2}		
Sb 124	60 da		G.I.Tract	Ingestion		4.8	4.8	0.17	0.17
		5.0	Lungs	Inhalation(I)		7.6	1.0×10^{-1}		93
			Bone	Inhalation	28	4.0×10^{3}	2.6×10^{3}		
		3.56	Bone	Ingestion		3.7×10^{4}	2.4×10^{4}		
Ir 192	70 da	5.88	Lungs	Inhalation(I)		7.0	7.8×10^{-1}	2.3	2.3
			G.I.Tract	Ingestion		7.8	7.8		
			Lungs	Inhalation(S)		1.6×10^{1}	1.6×10^{1}		2.5
		2.43	Kidneys	Inhalation	3.4	3.4×10^{3}	8.4		
		2.43	Kidneys	Ingestion		5.8×10^{3}	1.4×10^{1}		
Sc 46	85 da	6.56	Lungs	Inhalation(I)		5.2	5.2×10^{-1}	0.97	0.97
			G.I.Tract	Ingestion		5.8	5.8		
			Lungs	Inhalation(S)		1.2×10^{1}	1.2×10^{1}		2.0
		1.85	Spleen	Inhalation	6.0	3.7×10^{1}	1.2×10^{1}		
		1.85	Spleen	Ingestion		1.9×10^{4}	6.0×10^{3}		
S 35	87.1 da	6.65	Lungs	Inhalation(I)		1.2×10^{2}	1.2×10^{2}	1.4	
			G.I.Tract	Ingestion		1.4×10^{2}	1.4×10^{2}		
			Lungs	Inhalation(S)		2.8×10^{2}	2.8×10^{2}		0.94
		2.57	Skin	Ingestion	1.0×10^{2}	4.0×10^{2}	9.4×10^{1}		
Te 127	90	6.78	Lungs	Inhalation(I)		2.1×10^{1}	2.0	6.0	
			G.I.Tract	Ingestion		2.4×10^{1}	2.4×10^{1}		
			Lungs	Inhalation(S)		4.7×10^{1}	4.7×10^{1}		4.0
		1.85	Kidneys	Inhalation	4.0	5.0×10^{1}	1.6×10^{1}		
		1.85	Kidneys	Ingestion		1.4×10^{3}	4.4×10^{2}		

1184860

TABLE A

COMPARISON OF BODY BURDEN WITH MAXIMUM PERMISSIBLE SINGLE INTAKE AND MAXIMUM PERMISSIBLE WEEKLY INTAKE

Isotope	Half-life Physical	Half-life Effective Weeks	Critical Organ	Mode of Intake	Body Burden, µc	M.P. Single Intake, µc	M.P. Weekly Intake, µc	MPSI / Body Burden	MPWI / Body Burden
Ta 182	111 da		G.I.Tract	Ingestion		7.2	7.2	1.11	1.11
		8.3	Lungs	Inhalation(I)		9.0	7.2×10^{-1}		
			Liver	Inhalation		-	-		
		8.57	Liver	Ingestion	6.5	2.46×10^{4}	1.8×10^{3}		277
Sn 113	112 da	7.55	Lungs	Inhalation(I)		2.2×10^{1}	1.9		
			G.I.Tract	Ingestion		2.4×10^{1}	2.4×10^{1}	0.30	0.30
			Lungs	Inhalation(S)		4.9×10^{1}	4.9×10^{1}		
		6.29	Bone	Inhalation	8.0×10^{1}	8.7×10^{2}	9.0×10^{1}		1.1
		6.29	Bone	Ingestion		2.5×10^{4}	2.5×10^{3}		
Po 210	138.3 da		G.I.Tract	Ingestion		7.1×10^{-2}	7.1×10^{-2}	3.6	
			Lungs	Inhalation(S)		1.4×10^{-1}	1.4×10^{-1}		
		5.72	Spleen	Inhalation	2×10^{-2}	2.9×10^{-1}	3.3×10^{-2}		1.6
		8.28	Lungs	Inhalation(I)	7×10^{-3}	6.6×10^{-1}	5.3×10^{-2}		
		5.72	Spleen	Ingestion		3.9	4.4×10^{-1}		
W 185	140 da		G.I.Tract	Ingestion		20	20	0.29	0.29
		9.3	Lungs	Inhalation(I)		5.7×10^{1}	3.9		
			Bone	Inhalation	70	2.9×10^{3}	1.8×10^{3}		26
		0.68	Bone	Ingestion		8.8×10^{3}	5.6×10^{3}		
Ca 45	152 da	8.61	Lungs	Inhalation(I)		7.9×10^{1}	6.2		
			G.I.Tract	Ingestion		8.9×10^{1}	8.9×10^{1}	1.4	
		21.6	Bone	Inhalation	6.5×10^{1}	1.6×10^{2}	5.0		0.077
			Lungs	Inhalation(S)		1.8×10^{2}	1.8×10^{2}		
		21.6	Bone	Ingestion		2.6×10^{2}	8.2		
Zn 65	250 da	10.19	Lungs	Inhalation(I)		2.0×10^{1}	1.3		
			G.I.Tract	Ingestion		2.3×10^{1}	2.3×10^{1}	0.053	0.053
			Lungs	Inhalation(S)		4.6×10^{1}	4.6×10^{1}		
		3.00	Bone	Inhalation	4.3×10^{2}	1.6×10^{3}	3.3×10^{2}		0.77
		3.00	Bone	Ingestion		4.8×10^{3}	9.9×10^{2}		

1984011

TABLE A

COMPARISON OF BODY BURDEN WITH MAXIMUM PERMISSIBLE SINGLE INTAKE AND MAXIMUM PERMISSIBLE WEEKLY INTAKE

Isotope	Half-life Physical	Half-life Effective weeks	Critical Organ	Mode of Intake	Body Burden, μc	M.P.Single Intake, μc	M.P.Weekly Intake, μc	MPSI / Body Burden	MPWI / Body Burden
Ce 144 and Pr 144	275 da	10.5	Lungs	Inhalation(I)	5	4.8	3.1×10^{-1}	1.1	0.22
			G.I.Tract	Ingestion		5.4	5.4		
			Lungs	Inhalation(S)		1.1×10^{1}	1.1×10^{1}		
		25.7	Bone	Inhalation		4.3×10^{1}	1.1		
		25.7	Bone	Ingestion		2.1×10^{4}	5.6×10^{2}		
Cd 109 and Ag 109	330 da	10.94	Lungs	Inhalation(I)	4.0×10^{1}	9.5×10^{1}	5.8	2.8	0.28
			G.I.Tract	Ingestion		1.1×10^{2}	1.1×10^{2}		
		11.0	Liver	Inhalation		1.8×10^{2}	1.1×10^{1}		
			Lungs	Inhalation(S)		2.2×10^{2}	2.2×10^{2}		
		11.0	Liver	Ingestion		1.8×10^{4}	1.1×10^{2}		
Ru 106 and Rh 106	1.0 yr	11.2	Lungs	Inhalation(I)	4.0	4.4	2.6×10^{-1}	1.2	1.1
			G.I.Tract	Ingestion		5.0	5.0		
			Lungs	Inhalation(S)		1.0×10^{1}	1.0×10^{1}		
		2.72	Kidneys	Inhalation		1.9×10^{2}	4.3		
		2.72	Kidneys	Ingestion		9.4×10^{2}	2.1×10^{2}		
Na 22	2.6 yr		G.I.Tract	Ingestion	55	9.4	9.4	0.17	0.17
			Lungs	Inhalation(I)		6.7	3.0×10^{-1}		
		15.0	Total Body	Inhalation		8.3×10^{1}	1.3×10^{1}		0.18
		4.0	Total Body	Ingestion		6.4×10^{1}	1.0×10^{1}		
Tl 204	2.7 yr		G.I.Tract	Ingestion	180	16.7	16.7	0.09	0.09
			Lungs	Inhalation(I)		3.2×10^{1}	1.28		
		107	Muscle	Inhalation		4.3×10^{2}	1×10^{2}		0.55
		0.24	Muscle	Ingestion		4.7×10^{2}	1.1×10^{2}		
Pm 147	2.7 yr	13.4	Lungs	Inhalation(I)	1.2×10^{2}	9.9×10^{1}	5.0	0.92	0.26
			G.I.Tract	Ingestion		1.1×10^{2}	1.1×10^{2}		
			Lungs	Inhalation(S)		2.3×10^{2}	4.5×10^{1}		
		20.0	Bone	Inhalation		9.1×10^{2}	3.1×10^{1}		
		20.0	Bone	Ingestion		4.8×10^{5}	1.6×10^{4}		

1184862

COMPARISON OF BODY BURDEN WITH MAXIMUM PERMISSIBLE SINGLE INTAKE AND MAXIMUM PERMISSIBLE WEEKLY INTAKE

Isotope	Half-life Physical	Half-life Effective Weeks	Critical Organ	Mode of Intake	Body Burden, μc	M.P.Single Intake, μc	M.P.Weekly Intake, μc	MPSI / Body Burden	MPWI / Body Burden
Fe 55	2.91 yr	8.72	Blood	Ingestion	1.0×10^{3}	8.4×10^{2}	6.5×10^{1}		0.065
		13.04	Lungs	Inhalation(I)		1.1×10^{3}	5.7×10^{1}		
			G.I.Tract	Ingestion		1.3×10^{3}	1.3×10^{3}	1.3	
			Lungs	Inhalation(S)		2.6×10^{3}	2.6×10^{3}		
Co 60	5.3 yr	13.54	Lungs	Inhalation(I)		4.4	2.2×10^{-1}		
			G.I.Tract	Ingestion		5.0	5.0	1.7	1.7
			Lungs	Inhalation(S)		1.0×10^{1}	1.0×10^{1}		
		1.20	Liver	Inhalation	3.0	3.4×10^{2}	1.5×10^{2}		50
		1.20	Liver	Ingestion		6.0×10^{2}	2.6×10^{3}		
		1.28	Spleen	Inhalation		3.5×10^{3}	1.5×10^{3}		
		1.28	Spleen	Ingestion		6.1×10^{3}	2.5×10^{3}		
Eu 154	5.4 yr	13.6	Lungs	Inhalation(I)		8.0	4.0×10^{-1}		
			G.I.Tract	Ingestion		9.1	9.1	0.41	
			Lungs	Inhalation(S)		1.8×10^{1}	1.8×10^{1}		0.043
		117.1	Bone	Inhalation	2.2×10^{1}	1.6×10^{2}	9.4×10^{-1}		
		117.1	Bone	Ingestion		8.5×10^{4}	5.0×10^{2}		
H 3	12.5 yr	14.0	Lungs	Inhalation(I)		1.1×10^{3}	5.3×10^{1}		
			G.I.Tract	Ingestion		1.3×10^{3}	1.3×10^{3}	0.13	0.13
			Lungs	Inhalation(S)		2.6×10^{3}	2.6×10^{3}		
		2.71	T.Body	Ingestion	1.0×10^{4}	1.0×10^{4}	2.4×10^{3}		0.24
Sr 90 and Y 90	25 yr	14.12	Lungs	Inhalation(I)		6.6	3.2×10^{-1}		
			G.I.Tract	Ingestion		7.6	7.6	7.6	
			Lungs	Inhalation(S)		1.5×10^{1}	1.5×10^{1}		0.039
		386	Bone	Ingestion	1.0	2.2×10^{1}	3.9×10^{-2}		
Cs 137 and Ba 137	37 yr	14.15	Lungs	Inhalation(I)		1.2×10^{1}	5.8×10^{-1}		
			G.I.Tract	Ingestion		1.3×10^{1}	1.3×10^{1}	0.14	
			Lungs	Inhalation(S)		2.6×10^{1}	2.6×10^{1}		
		2.43	Muscle	Ingestion	90	2.6×10^{1}	6.4		0.071

REFER TO APPENDIX "C"

1184863

TABLE A

COMPARISON OF BODY BURDEN WITH MAXIMUM PERMISSIBLE SINGLE INTAKE AND MAXIMUM PERMISSIBLE WEEKLY INTAKE

Isotope	Half-life Physical	Half-life Effective weeks	Critical Organ	Mode of Intake	Body Burden, μc	M.P.Single Intake, μc	M.P.Weekly Intake, μc	MPSI / Body Burden	MPWI / Body Burden
Ni 63	85 yr		G.I.Tract	Ingestion		6.1	6.1	0.06	0.06
		19.0	Lungs	Inhalation(I)		3.7×10^{2}	1.4×10^{-1}		
			Liver	Inhalation	110	1.4×10^{4}	6.6×10^{2}		6.0
		1.1	Liver	Ingestion		2.4×10^{4}	1.1×10^{4}		
C 14	5720 yr	14.3	Lungs	Inhalation(I)		1.3×10^{2}	6.1		
			G.I.Tract	Ingestion		1.4×10^{2}	1.4×10^{2}	0.56	
			Lungs	Inhalation(S)		2.9×10^{2}	2.9×10^{2}		
		5.00	Fat	Ingestion	2.5×10^{2}	3.1×10^{2}	4.0×10^{1}		0.16
		25.7	Bone	Ingestion	1.5×10^{3}	2.2×10^{3}	5.8×10^{1}		
Tc 99	2.1×10^{5} yr		G.I.Tract	Ingestion		47.7	47.7	1.4	1.4
		19.0	Lungs	Inhalation(I)		74.0	2.9		
			Kidneys	Inhalation	33	1.8×10^{3}	1.2×10^{3}		46.0
		0.57	Kidneys	Ingestion		1.8×10^{3}	1.2×10^{3}		
Ni 59	2 to 3 x 10^{5} yr	14.28	Lungs	Inhalation(I)		1.3×10^{2}	6.2		
			G.I.Tract	Ingestion		1.5×10^{2}	1.5×10^{2}	3.8	3.8
			Lungs	Inhalation(S)		3.0×10^{2}	3.0×10^{2}		
		1.14	Liver	Inhalation	3.9×10^{1}	5.0×10^{3}	2.3×10^{3}		59
		1.14	Liver	Ingestion		8.8×10^{3}	4.0×10^{3}		
Cl 36	~3.4 x 10^{5} yr	14.3	Lungs	Inhalation(I)		2.5×10^{1}	1.2		
			G.I.Tract	Ingestion		2.9×10^{1}	2.9×10^{1}	0.15	0.15
			Lungs	Inhalation(S)		5.8×10^{1}	5.8×10^{1}		
		4.15	T.Body	Ingestion	2.0×10^{2}	2.4×10^{2}	3.7×10^{1}		0.19

1198811

TABLE B

COMPARISON OF M. P. SINGLE INTAKE AND SINGLE WEEKLY INTAKE WITH CONTINUOUS WEEKLY INTAKE BASED ON NBS 52 MPC IN AIR AND WATER

Isotope	Critical Organ	Single Intake, μc/week		Continuous Weekly Intake, μc/week	
		MPSI	MPWI	AIR	WATER
K 42	Muscle	2.0×10^{2}	2.0×10^{2}	2.8×10^{2}	1.5×10^{2}
Na 24	T. Body	1.7×10^{2}	1.7×10^{2}	2.8×10^{2}	1.2×10^{2}
I 131	Thyroid	4.7×10^{-1}	2.19×10^{-1}	4.2×10^{-1}	4.6×10^{-1}
P 32	Bone	4.7×10^{1}	1.4×10^{1}	1.4×10^{1}	3.1
Fe 59	Blood	9.8	1.6	2.1	1.5
Ca 45	Bone	1.6×10^{2}	5.0	4.2	7.7
Fe 55	Blood	8.4×10^{2}	6.5×10^{1}	8.4×10^{1}	6.2×10^{1}
H 3	T. Body	1.0×10^{4}	2.4×10^{3}	2.8×10^{3}	3.1×10^{3}
Sr 90 & Y 90	Bone	2.2×10^{1}	3.9×10^{-2}	2.8×10^{-2}	1.2×10^{-2}
C 14	Fat	3.1×10^{2}	4.0×10^{1}	1.4×10^{2}	4.6×10^{1}

1184865

ASST. GEN. COUNSEL

AUG 16 1954

TABLE OF CONTENTS

1184866

118867

1184868

FOREWORD

In accordance with provisions of the Atomic Energy Act of 1946, the U. S. Atomic Energy Commission is engaged in an extensive program of producing and distributing radioactive and stable isotopes. Isotopes have proved to be invaluable diagnostic and therapeutic agents and highly useful tools in scientific research, industry, education, agriculture, and other applications. During the first 8 1/2 years of the distribution program, more than 47,000 shipments of radioisotopes produced in Commission facilities were delivered to some 21,000 domestic institutions including hospitals, clinics, research laboratories, industrial firms, and universities.

The Isotopes Division, Oak Ridge, Tennessee, is responsible for administering the AEC's program of authorizing the procurement, possession, and use of isotopes and irradiation services. Inasmuch as radioactive materials may prove harmful if improperly handled, radioisotopes may be procured only after review of applications indicates that radiological safety will be maintained in the proposed use of the radiomaterial. The Isotopes Division receives applications and issues authorizations for the procurement of radioisotopes; Commission sales are accomplished through the AEC National Laboratories.

This manual includes (1) information on procedures for procurement of reactor-produced radioisotopes, concentrated stable isotopes, and irradiation services; (2) information concerning technical and information services available from Commission sources; (3) recommendations for radiological health-safety; and (4) regulatory requirements. The information furnished herein is relatively brief. Requests for more

1184869

detailed information or application forms should be addressed to:

U. S. Atomic Energy Commission
Post Office Box E
Oak Ridge, Tennessee
Attention: Isotopes Division

I. GENERAL INFORMATION

THE ATOMIC ENERGY ACT authorizes the Commission to distribute radioisotopes to applicants seeking such materials for research or development activity, medical therapy, industrial uses, or such other useful applications as may be developed.

THE ACT further provides that the Commission shall not distribute radioisotopes to an applicant, and shall recall any distributed materials from any applicant, who is not equipped to observe or who fails to observe such safety standards to protect health as may be established by the Commission or who uses such materials in violation of law or regulation of the Commission or in a manner other than as disclosed in the application therefor.

REGULATIONS establishing instructions and standards governing the procurement, delivery, possession, use, transfer (including export), and disposal of radioisotopes, a statement of authority of the Director, Isotopes Division, and an appeals procedure, which an applicant, denied materials or services by order of the Director, Isotopes Division, must follow to obtain a hearing have been published by the Commission under Title 10, Part 30, of the Code of Federal Regulations.*

RADIOACTIVE AND STABLE ISOTOPES are sold (or loaned) by the Commission through its AEC National Laboratories, or by authorized suppliers. AEC National Laboratories are the primary isotope producers or manufacturers. Suppliers are persons or firms who further process materials obtained from AEC National Laboratories.

---

* The regulations as of July 24, 1954, are reprinted in Section VIII of this Manual.

1184811

CATALOGS AND PRICE LISTS, or a brochure describing available isotopes and services may be obtained from a number of private and commercial suppliers as well as the following AEC National Laboratories:

Oak Ridge National Laboratory
Carbide & Carbon Chemicals Company
Post Office Box P
Oak Ridge, Tennessee

Attention: Radioisotope Sales Department

Argonne National Laboratory
University of Chicago
Post Office Box 299
Lemont, Illinois

Attention: Special Materials Department

Brookhaven National Laboratory
Associated Universities, Inc.
Upton, Long Island, New York

Attention: Isotopes and Special Materials Group

Mound Laboratory
Monsanto Chemical Company
Miamisburg, Ohio

Attention: Operations Division

National Reactor Testing Station
Phillips Petroleum Company
P. O. Box 1221
Idaho Falls, Idaho

Attention: Atomic Energy Division

APPLICATIONS FOR RADIOISOTOPE PROCUREMENT and REQUESTS FOR STABLE ISOTOPES should be sent to the:

U. S. Atomic Energy Commission
Post Office Box E
Oak Ridge, Tennessee

Attention: Isotopes Division

The Isotopes Division receives applications and issues authorizations for the procurement of radioactive and stable isotopes, isotope-labeled compounds, and related services.

WRITE TO THE ISOTOPES DIVISION for application forms, information on policies and procedures, and related services.

WRITE TO AEC NATIONAL LABORATORIES AND SUPPLIERS for catalogs and price lists, information on availability of materials and services, production and shipping schedules, and information on invoices and billing.

NATURALLY-OCCURRING RADIOISOTOPES. The Isotopes Division authorizes the distribution of reactor-produced and some cyclotron-produced radioisotopes. For information concerning procurement of uranium and thorium write to Licensing Controls Branch, Division of Construction and Supply, U. S. Atomic Energy Commission, 1901 Constitution Avenue, N. W., Washington 25, D. C.

II. RADIOISOTOPES

Available Materials and Services

THE BASIC PRODUCTS available from Commission facilities are:

1. Unprocessed irradiated materials
   (a) Service irradiations of targets furnished by the applicant.
   (b) Routinely irradiated batches or "units."
2. Chemically processed radioisotopes
   (a) From target materials.
   (b) From uranium (fission products).

Processed radioisotopes are available from Commission distributors primarily in simple chemical forms.

Radioisotopes and irradiations of elements of atomic number 3 to 83 inclusive are routinely available for all uses. In addition, Tritium and Polonium 210 are available for research uses. Service irradiations of elements above atomic number 83 are not normally available but will be considered provided there are no security restrictions (such as for the irradiation of uranium) and the target material will not affect the safety of the reactor.

AEC Facilities for Radioisotope Production

OAK RIDGE NATIONAL LABORATORY. The graphite reactor at ORNL is the major source of AEC-supplied radioisotopes. The approximate flux*

---

* FLUX is the number of neutrons passing through a square centimeter in one second.

1184874

of this reactor is $1 \times 10^{11} - 7 \times 10^{11}$. The maximum sample size which can be produced is 3/4" dia. x 2-7/8" for an irradiated unit and 3½" x 3½" x 10" for a service irradiation. ORNL is the primary distributor of separated isotopes.

The Low Intensity Test Reactor (LITR) supplements the graphite reactor where a higher flux is required. The flux is approximately 1×10^{13} and the maximum sample size for an irradiated unit is 3/8" dia. x 1-3/4".

Approximately 100 different radioisotopes are produced and distributed by ORNL. Radioisotopes are available in two forms: (1) irradiated units, which are unprocessed irradiated target materials, shipped without measurement of radioactivity, and (2) processed radioisotopes, the majority of which are sold in solution and the radioactivity measured before shipment. The graphite reactor at ORNL is shut down for charging and removal of isotopes twice a week. In special cases shorter irradiations can be performed by means of a pneumatic tube. Acceptable materials must be relatively non volatile at a temperature of 150° C; in some cases special canning may be used to permit irradiation of more volatile materials.

Special services available from ORNL include neutron activation analysis, and disposal of radioactive wastes.

BROOKHAVEN NATIONAL LABORATORY. The Brookhaven reactor has an approximate flux of $1 \times 10^{11} - 4 \times 10^{12}$. The maximum sample size is 3/4" dia. x 2-1/8" for an irradiated unit and 12" x 12" x 24" for a service irradiation. An important characteristic of this reactor is the fact that irradiation facilities can be cooled -- air, water or liquid nitrogen.

The reactor possesses a hole for larger samples and facilities for medical treatment. An endless chain conveyor permits removing samples without closing down the pile.

NATIONAL REACTOR TESTING STATION. The Materials Testing Reactor (MTR) participates in the isotope program in three ways:

(a) furnish service irradiations of special materials at high fluxes

(b) produce some isotopes with very high specific activities which otherwise would not be available. Available fluxes range from 1 to 5 x 10^{13}.

(c) furnish facilities for intense gamma irradiations.

ARGONNE NATIONAL LABORATORY. The Argonne Research Reactor (CP-5) has a flux of approximately 5 x 10^{12}. These facilities are available primarily to institutions participating in the ANL program.

MOUND LABORATORY. Polonium 210 sources are available from Mound Laboratory.

REFINED, PROCESSED OR FABRICATED RADIOACTIVE MATERIALS. An increasing number of commercial and industrial firms and laboratories supply special materials and services:

1. Chemical Processing - special modification of the basic reactor products; synthesis of major intermediates; synthesis of complex compounds. (Although many isotope-labeled compounds have been synthesized in Commission laboratories, sale has been limited generally to those compounds that are not available from private industry.)

2. Isotope-labeled drugs.

3. Fabrication - special radiation sources and devices for industrial use.

4. Consultation Service - engineering, feasibility, and cost studies.

1184876

5. Instrumentation and Radioisotope Handling Equipment - especially designed for radioisotope technology.

6. Reference Sources - Secondary beta and gamma-ray standards and reference sources are available from the National Bureau of Standards and from commercial suppliers.

Pricing Policy

Prices and charges for radiomaterials distributed by the Commission are based on actual costs to the Commission. Price reductions are made as economies are effected in operations. For example, Carbon 14 has been reduced from $375 per millicurie to its present price of $36 per millicurie. Separated fission product prices have also been reduced as separation and purification processes have been improved.

Prices charged for isotope-labeled compounds prepared in Commission laboratories are set so that costs will be recovered. Prices charged by private suppliers of labeled compounds are fixed by individual laboratories, and no control is exercised by the Commission.

Radioisotope Procurement Procedures

APPLICATION. Complete Form AEC-313, "Application for Radioisotope Procurement," and mail to the Isotopes Division, U. S. Atomic Energy Commission, Oak Ridge, Tennessee. Complete a separate Form AEC-313 for each radioisotope and special irradiation service desired. The application form provides for statements of (1) experience of applicant, or employees, with radiation and radioactive materials, (2) proposed use of the radiomaterial, and (3) equipment and facilities available for

1184877

safe handling of radioisotopes. The Isotopes Division, in evaluating an application, is primarily interested in radiological health safety details. It is to be emphasized that complete answers should be given to all pertinent questions on the form thereby minimizing the delays occasioned in returning the application or writing for more complete information. Copies of the application form may be obtained from the Isotopes Division.

QUANTITIES. Each application should cover the procurement of a specified quantity of a single radioisotope. The quantity of radioisotope applied for on Form AEC-313 may cover the estimated requirements for one year and may be obtained from the AEC National Laboratory or supplier in partial shipments - not to exceed the specified total quantity.

AUTHORIZATION. Form AEC-374, "Authorization for Radioisotope Procurement" will be sent to the applicant whose application is approved.

PROCUREMENT. Send purchase order to the AEC National Laboratory or supplier after Form AEC-374 has been received. All arrangements for purchase, shipment and payment for radioisotopes should be made directly with the AEC National Laboratory or supplier.

Do not transfer radioisotopes except to another person having a Form AEC-374 authorizing receipt of the material, unless otherwise permitted by law or regulation.

Radioisotope Distribution Policies

GENERAL POLICY. "The Commission considers it to be of vital importance to make isotopes available to all qualified users in quantities

1184878

as large as can be profitably used, in variety as great as can be developed, and at the lowest possible cost" - Quoted from the Third Semiannual Report of the USAEC.

The language of the Atomic Energy Act is broad in authorizing the Commission to distribute radioisotopes for "research or development activity, medical therapy, industrial uses, or such other useful applications as may be developed." On the other hand, throughout the Act there are provisions relating to safety and protection of health. Therefore, Commission policies for the isotope distribution program, and for issuing authorizations, are established primarily on the basis of radiological safety.

The Application (Form AEC-313) is designed to provide the Commission with the information needed to make a reasonable determination of the health and safety factors incident to the proposed use. The general requirements are that the applicant be equipped to handle safely the quantity of radiomaterial requested for the use proposed by having:

a. Trained and experienced personnel.

b. Suitable equipment and facilities (handling devices, work areas, shields, measuring and monitoring instruments).

THE USE proposed by the applicant must come within those prescribed by the Atomic Energy Act. Applications will be approved for the following specific uses provided the experience, equipment, and facilities of the applicant are adequate for the activity desired.

1. RESEARCH AND DEVELOPMENT. This use is specifically defined in the Atomic Energy Act as "theoretical analysis, exploration, and

experimentation, and the extension of investigative findings and theories of a scientific or technical nature into practical application for experimental and demonstration purposes, including the experimental production and testing of models, devices, equipment, materials, and processes."

2. MEDICINE. The use of radioisotopes in humans, for research, diagnosis and therapy, is authorized within recommendations made periodically by the Subcommittee on Human Applications of the AEC Advisory Committee on Isotope Distribution. Medical research institutions, hospitals, clinics, or other medical organizations may apply for authorization to use radioisotopes for research, diagnosis, and therapy. While uses for routine diagnosis and therapy may be authorized for private practice, it is required, generally, that all investigational work and nonroutine diagnosis and therapy be conducted in an institution. In all cases the physician must be licensed in his state to dispense drugs in the practice of medicine.

Authorizations issued by the Commission for the medical use of radioisotopes are usually in accord with recommendations of the Subcommittee on Human Applications of the AEC Advisory Committee on Isotope Distribution. Section 30.21 (b) thru (d) of the Radioisotope Distribution Regulations contains special requirements applicable to human use. (See Section VIII).

General policies regarding the two broad categories of institutional use and private practice are outlined below.

a. Staff or Institutional Use.

(1) Isotope Committee. The medical research institution, hospital, clinic, or other medical organization, must appoint a local isotope

committee (see Section VII) to evaluate all proposals for research, diagnostic and therapeutic use of radioisotopes within that institution.

(2) Clinical Facilities. These should be adequate for the clinical care of patients and for safe handling and disposal of radioisotopes. Tracer and diagnostic studies that may not require clinical facilities should be explained in the application.

(3) Experience. The physician designated as the individual user (Item 3, Form AEC-313), must have experience in (a) the clinical use of radioisotopes for the uses proposed, (b) the handling and administration of radioactive materials, and (c) the management of clinical cases.

b. Individual Use or Private Practice.

(1) Isotope Committee. No local isotope committee is required.

(2) Clinical Facilities. The physician must have access to a hospital possessing adequate facilities to hospitalize and monitor radioactive patients whenever it is advisable. For uses involving low doses the applicant physician should have one or more hospitals forward a letter to the Isotopes Division indicating a willingness to admit the physicians radioactive patients if this should prove necessary or desirable. If doses in excess of 30 millicuries are contemplated the hospital should also furnish information regarding its facilities and procedures for radiological safety. This information regarding monitoring, disposal, instruction of nursing personnel, etc., may be conveniently submitted on a Form 313 completed by the hospital.

(3) Experience. The physician must have more clinical experience using radioisotopes than that generally required for staff use.

The physician must have actual experience in handling and administration of radioisotopes. The physician must furnish suitable evidence of this experience; a statement from the local isotope committee under which he received his training indicating the amount and nature of his experience may be submitted as evidence.

c. General Remarks on Medical Use.

(1) It is to be noted that radioisotopes currently available from many of the AEC National Laboratories and suppliers are not guaranteed to be of quality and assay suitable for internal administration to humans. An applicant for radioisotopes for human use should include in his application information regarding his plans for processing and assay of the radioisotope prior to medical use and his pertinent experience and facilities for such processing unless he plans to obtain material from a supplier who holds an "Effective New Drug Application" for the radioisotope.

(2) All applications for radioisotopes to be used in human beings are subject to review by the Atomic Energy Commission's Medical Advisors.

(3) Short half-life radioisotopes (less than 30 days) are most commonly authorized for use in humans. Long half-life radioisotopes such as Carbon 14, Cobalt 60 and Iron 59 have been authorized for certain types of studies.

(4) Prior Research. Applications for new therapeutic use should be supported, whenever possible, by data from animal experiments. Also, diagnostic or tracer experiments in humans should usually precede therapeutic use.

1184882

(5) Use of Iodine 131 in Diagnosis of Thyroid Function Only. Applicants frequently propose that they will use I 131 exclusively for diagnosis of thyroid function. Under such circumstances access to hospital facilities is not essential. It is desirable, however, for diagnostic work that: (a) the physician should procure the radio-material from a supplier in precisely calibrated solutions not to exceed 500 microcuries per vial of solution or 1000 microcuries per package of individual dose capsules, (b) the physician should have worked for at least 30 hours in a laboratory or institution previously approved to receive I 131 for diagnostic and therapeutic use, (c) this training should include active participation in measurement and diagnosis of at least 10 cases.

(6) Dosage. Administration of radioisotopes should always be limited to the minimum activity required to accomplish the objective of the work. When no diagnostic or therapeutic benefit can reasonably be anticipated, the dosage to the critical tissue (tissue of maximum concentration) should not exceed 300 millirad* per week from a single or repeated administration. (There are instances when the disease from which a patient is suffering may justify the use of larger doses of radioactivity than those recommended for use in normal subjects.) Applications for new diagnostic, therapeutic, or investigative studies should include detailed statements concerning the following points:

(a) Tissue of highest concentration and the relative concentration

---

* "Millirad" is one thousandth of a "Rad." "Rad" is a unit of absorbed dose of ionizing radiation and is 100 ergs per gram. In the case of dose to personnel this means 100 ergs per gram of average soft tissue.

1184883

therein. (b) Relative concentrations in the tissue of interest and particularly radiosensitive tissues, such as the gonads and hematopoietic

(3) Radioactivity present in products sold to the public.

The safety factors to be considered in industrial uses are much the same as those pertinent to use of radioisotopes in laboratories. If the activity is well shielded, otherwise controlled, and under the supervision of trained workers, the use would be considered safe. The levels of beta and gamma activity permitted in products sold to the public should be controlled so that radiation at the surface is negligible and the product so constructed that the possibility of ingestion or inhalation of radioactivity is also negligible. Such applications, although not expressly discouraged, are reviewed very carefully and conservatively from a radiological safety viewpoint. In addition, when products are stored, monitoring should show that the radiation level is within safe limits.

b. Industrial Radiography.

The increasing use of Cobalt 60, Iridium 192, and other radiomaterials for industrial radiography, both within institutions and in the field, has pointed up the necessity for a sound radiological safety program when handling relatively large radioactive sources for such purposes.

Applicants seeking radiocobalt for industrial radiography may or may not have used radium or X-ray machines previously. Experience gained through radiographic testing either with radium or with X-ray machines should be indicated on the application. Although X-ray experience should prove to be a helpful background to the applicant, it alone will not ordinarily qualify him to use gamma emitting radioisotopes since the techniques used in the two types of radiography are

quite different. In some instances, when the radioactive source is relatively small, X-ray experience alone may be adequate.

Radiation exposure records are particularly necessary in connection with radiographic use of radioisotopes. Therefore, attention is called to Title 10, Part 30, Sections 30.50 thru 30.54 of Code of Federal Regulations: Radioisotope Distribution, in which certain records are required. As stated in these regulations, the records are to be made available to the Atomic Energy Commission upon request.

Users of sealed gamma emitting sources for field radiography must obtain film badge service and routinely report to the Isotopes Division personnel exposures as determined by such film badges for three consecutive months. Under certain circumstances dosimeters or pocket chambers also may be desirable. Further, a radiation survey instrument should be on hand or immediately available to each person or team using such sources. The lower range of this instrument should be suitable for monitoring permissible levels in continuously occupied areas and the upper range should be sufficiently high as to permit measurement of the maximum radiation likely to be encountered from the source, as for example, in locating a source should it be lost.

In some instances institutions or firms, applying for radioisotopes for industrial radiography, furnish on-the-spot training for their radiographic operators. If such a course is to be given, the application for the radioisotope should describe completely the type and extent of instruction to be offered both to supervisory personnel who will direct the handling of the isotope and to non-supervisory personnel who will actually use the material. All pertinent information should be

1184886

included such as instructions provided personnel regarding biological effects of radiation and safety instructions to be followed by operating personnel and others.

The following information should be included in an application, or attached to the application, when requesting radioisotopes for radiography.

(1) Description of the training and experience with high energy gamma emitting radioisotopes of all persons who will use or supervise the use of radioisotopes, with particular reference to types and amounts of radioactivity handled.

(2) Sensitivity range and type of survey meter. If a meter is not now available what provisions are made for determining safe working distances and locating possible lost sources?

(3) What is the maximum weekly personnel radiation exposure or dose which will be permitted?

(4) Methods of calibrating and processing film badges. (Name of film badge supplier will be of assistance, if details of calibration and processing are not known.)

(5) Will pocket meters be used? If so, how frequently will they be read and how will they be calibrated?

(6) Description of remote handling equipment, with particular reference to length of device and type of connection to the source. If "fish pole and string" is to be used, describe procedures and facilities for attaching string, chain, etc., to source and repairing them when broken. How much radiation are personnel expected to receive while attaching this string, chain, etc., to source? How long will unshielded source be handled or carried between "setups"?

(7) Description of available shielding equipment, both storage containers and shielding during operation. If source is to be used in a gamma exposure shield, describe minimum thickness of shielding available, type of shielding material, and mechanism for bringing source to "on" or "off" positions.

(8) Estimate of time involved in removing source from container and positioning it, and returning source to container after exposure. Approximately how many exposures will be made each week by any one person?

(9) Description of exposure room, if any, giving its geographical relationship to adjoining work areas and an estimate of the radiation intensity in these adjacent areas when (a) the source is in use, and (b) when the source is in its container.

(10) What measures are to be taken to prevent access of unauthorized persons to the site of operation?

(11) Will the source be used only at the address stated on the application or in the field?

(12) Do you plan to encapsulate the source or do you plan to purchase an encapsulated source from a commercial firm? If you plan to do the encapsulation in your own laboratories describe in detail procedures to be followed, equipment and facilities to be employed, prior experience in this technique, and estimated personnel radiation exposure expected in carrying out the operation.

c. Encapsulation of Cobalt 60. Metallic Cobalt 60 to be used as a radiation source must be encapsulated prior to use. This precaution is

1184888

necessary since the oxide created on the surface of neutron irradiated Cobalt 60 tends to flake off thereby presenting a contamination problem. Other gamma sources should be encapsulated suitably for manipulation. AEC National Laboratories are prepared to encapsulate Cobalt 60 for all Federal agencies, and AEC facilities, including both the encapsulation service and capsule if desired. If the Federal agency or AEC facility wishes to furnish its own capsule, a drawing of the capsule should be forwarded to the laboratory to assure that it will be adaptable to remote-handling equipment.

As a general rule, AEC National Laboratories will not furnish capsules or pre-encapsulated sources to persons, other than Federal agencies or AEC facilities, if such pre-encapsulated sources are "routinely available," from commercial suppliers. Consideration will be given, however, to the encapsulation of any source, regardless of activity, if the user is unable to obtain such source through commercial channels.

General Authorizations

Most authorizations are issued for the procurement of a specified quantity of a single radioisotope. However, under certain conditions, "General" Authorizations are issued for the procurement of any quantity of any reactor-produced radioisotope (of atomic number 3 to 83 inclusive), from any AEC National Laboratory or supplier. General authorizations are available for (1) research and development activity, (2) medical use and (3) processing of radioisotopes for resale to other authorized persons.

Standard application forms may be obtained from the Isotopes Division for the types of general authorizations described below.

1. GENERAL AUTHORIZATIONS FOR RESEARCH AND DEVELOPMENT. A General Authorization for research and development permits the applicant to use radioisotopes at a specified location for any "research and development activity" as defined on page ____ of this Manual. To qualify for such a general authorization, the applicant must have

a. Received a reasonable number of "Authorizations for Radioisotope Procurement" for a variety of radioisotopes for a variety of research and development activities.

b. Established an institutional isotope committee (see Section VII) which will review and approve, in advance of purchase of radioisotopes, proposals for use of radioisotopes in the institution.

c. Appointed a radiological safety officer (see Section VII).

2. GENERAL AUTHORIZATIONS FOR MEDICAL USE OF RADIOISOTOPES. A General Authorization for medical use of radioisotopes permits the applicant to use radioisotopes at a specified location for any clinical use approved by the medical isotope committee. To qualify for such a general authorization, the applicant must have

a. Received a reasonable number of "Authorizations for Radioisotope Procurement" for a variety of radioisotopes for a variety of clinical studies in humans.

b. Established a medical isotope committee (see Section VII) on human uses which will review and approve, in advance of purchase

1184890

of radioisotopes, proposals for clinical use of radioisotopes in the institution.

c. Appointed a radiological safety officer (see Section VII).

3. GENERAL AUTHORIZATIONS FOR PROCESSING. A General Authorization for processing radioisotopes permits the applicant to purchase any quantity of any radioisotope for processing and resale to other authorized persons. To qualify for such a general authorization the applicant must have

a. Received a reasonable number of "Authorizations for Radioisotope Procurement" for processing and resale of a variety of radioisotopes.

b. Appointed a radiological safety officer (see Section VII).

Annual renewal of a general authorization is subject to review of the applicant's records and facilities by a member of the radiological safety staff, Isotopes Division.

Sealed Sources

A SEALED SOURCE means a radioactive material encased in, and to be used in, a container, such as metal, glass, or plastic, in a manner intended to prevent leakage of the radioactive material.

THE CONTAINER must be highly resistant to damage due to (1) action of chemicals outside the container, (2) action of chemicals inside the container, (3) radiation from the encased radioactive materials, (4) vibration or other mechanical injury, (5) thermal stress, and (6) vapor pressure produced by the contents.

THE SOURCE HOLDER is the chamber, box, or other enclosure which, as an integral part of the equipment, houses the container.

MANUFACTURERS AND SUPPLIERS of sealed sources must include the following information on Form AEC-313:

1. The amount of activity in each source.
2. A description of what the source is designed to do.
3. A description of the source design and fabrication.
4. Details of pre-delivery leak tests.
5. Description of warning labels appearing on the source and/or upon the device incorporating the source.
6. Safety features of the device designed to minimize radiation exposure to personnel.
7. Instructions provided to customer regarding safe use of the device.

Radioisotope Order Blank, Form AEC-375

The "Radioisotope Order Blank," Form AEC-375, has been prepared for use by all Federal agencies ordering radioisotopes, or irradiation services from AEC National Laboratories. No other type of order blank, purchase order, or contract with Federal agencies will be accepted by AEC National Laboratories.

Federal agencies after having executed Form AEC-313, Application for Radioisotope Procurement and received an Authorization for Radioisotope Procurement, Form AEC-374, will submit the latter form (unless previously filed with the AEC National Laboratory) together with this Order Blank to the AEC National Laboratory.

1184894

When submitting this order form, the requisitioning agency should furnish a prepared bill of lading on which shipment will be made by the AEC National Laboratory. If such bill of lading is not furnished, shipment will be made collect on a commercial bill of lading to be converted at destination.

The United States Atomic Energy Commission is authorized by the Atomic Energy Act, as amended, to distribute by-product materials (Radioisotopes). The AEC utilizes the services of the contractors operating its laboratories to perform these distribution functions for the AEC under cost-type contractual arrangements whereby expenses of the laboratory are borne by the AEC and revenue from distribution of radioisotopes, special irradiation services, and other services is applied toward reduction of operating costs. Service fees and charges are set by the AEC.

The operating contractor of the AEC National Laboratory accepting the order will retain the original and return an accepted copy of the order to the requisitioning agency. This form may be used also by a Commission-owned facility in lieu of a purchase order when ordering radioisotopes or irradiation services from another Commission facility.

Supplies of Form AEC-375 may be obtained from the Isotopes Division.

Certificate of Compliance with Federal Food, Drug, and Cosmetic Act

If radioisotopes are to be administered to humans or animals and such radioisotopes are to be procured from an AEC National Laboratory, a signed copy of "Certificate of Compliance with Federal Food, Drug and

Cosmetic Act," Form AEC-465 should be forwarded with the purchase order to the AEC National Laboratory.

If radioisotopes are procured from commercial suppliers for human or animal use, it may be necessary to file with the supplier a statement similar to that which appears on Form AEC-465.

Authorization-Exempt Quantities of Radioisotopes

Section 30.13 (a) of the Radioisotope Distribution Regulations (see page ____) provides that the quantities of radioisotopes listed in section 30.71 schedule B: Exempt Quantities, are exempt from the requirements of sections 30.20 through 30.53. These "authorization-exempt quantities" may be procured from a distributor or supplier without the necessity of filing an "Application for Radioisotope Procurement," with the Isotopes Division and receiving an "Authorization for Radioisotope Procurement."

It is to be noted, however, that these quantities may not be combined or altered in such a way as to increase the radioactivity of such scheduled quantities. Further, these "authorization-exempt quantities" may not be administered externally or internally to a human being except as permitted by a valid authorization. These quantities must be used, stored, or handled in accordance with such radiological health-safety standards as may be established by Commission regulation or order. It is not to be assumed that such quantities are necessarily harmless or can be handled indiscriminately.

1184893

Patent Policy

INVENTIONS OR DISCOVERIES made by persons using radioisotopes or using or manufacturing isotope-labeled compounds will be subject to patenting by the inventor in accordance with normal industrial practices. The Commission makes no reservations concerning patent rights to inventions and discoveries made by persons who receive radioactive materials pursuant to the Commission's regular program of radioisotope distribution. Similar policies will govern inventions or discoveries made by persons using material which has been subjected only to a service irradiation by the Commission or one of its contractors pursuant to the regular program for service irradiation of material.

III. STABLE ISOTOPES

Available Materials and Services

CONCENTRATED STABLE ISOTOPES prepared in Commission facilities are available, upon approval by the Isotopes Division, as follows:

Deuterium

Oxygen 18

Helium 3

Boron 10 and Boron 11

Argon 38

Electromagnetically-concentrated stable isotopes (available on loan only).

COMMERCIAL AND PRIVATE SUPPLIERS process and manufacture, for resale, isotope-labeled compounds and instruments making use of enriched isotopes listed above.

OTHER STABLE ISOTOPES such as Carbon 13 and Nitrogen 15 may be purchased from suppliers without filing a request with the Commission.

Write to AEC National Laboratories and suppliers for current catalogs and price lists.

Stable Isotope Procurement Procedures

REQUEST. Complete "Stable Isotope Request," Form AEC-100, and mail to the Isotopes Division. Complete a separate request for each isotope. If electromagnetically-concentrated stable isotopes are desired, the request should ask for a realistic minimum quantity of material which can be used in the proposed program. A signed "Agreement

1184895

for Loan of Electromagnetically-concentrated Stable Isotopes" should accompany an initial request and is applicable to subsequent requests.

APPROVAL. The approved request will be returned to the applicant by the Isotopes Division.

PROCUREMENT. Send purchase order together with a copy of the approved request to the supplier. NOTE: Make procurement and shipping arrangements directly with suppliers.

Do not transfer stable isotopes procured upon approval of the Commission without prior consent of the Isotopes Division.

Stable Isotope Distribution Policies

GENERAL POLICY. Since no radiological health hazard is associated with the use of concentrated stable isotopes, approval of a request is based only on availability of the materials and feasibility of the proposed use.

TIME LIMITS FOR PROCUREMENT. An approved request for electromagnetically-concentrated stable isotopes is valid for three months after date of issue. If the isotope is not procured within that time a new request must be submitted.

ELECTROMAGNETICALLY-CONCENTRATED ISOTOPES. Because of limited supply, electromagnetically-concentrated stable isotopes are available only on loan. Requests for investigations which will not consume or dilute the sample will be given priority. Samples will be loaned for the time required to perform the investigation, but not to exceed a period of six months. At the end of the loan period samples must be returned promptly with a certificate describing the use and dilution

of the material (in accordance with terms and conditions of the "Agreement for Loan"). If, at the end of the loan period, an investigation is not complete, an extension of the loan period may be requested.

1184897

IV. INTERNATIONAL DISTRIBUTION

Export

MATERIALS AND SERVICES. Reactor-produced radioisotopes, irradiation services, neutron activation analyses, and concentrated stable isotopes that are routinely available under the domestic program are also available for sale to foreign applicants. Tritium and Polonium 210 are not available for export.

USES. Subject to supply and reactor-space limitations, radioisotopes, irradiation services and stable isotopes may be procured for use in: scientific, medical, and industrial research; medical therapy; and industrial applications.

PROCEDURE. Each government interested in having isotope shipments made to users in its country is requested to appoint a representative or agent in the United States to handle matters connected with isotope procurement. Individual applications should be submitted to the Isotopes Division by or through the designated representative. (Names of designated representatives or agents and copies of application forms may be obtained by writing to the Isotopes Division.)

DESIGNATED REPRESENTATIVE - APPOINTMENT PROCEDURE. Each foreign government desiring to appoint an official representative for isotope procurement should address a note to the Secretary of State, stating:

1. The name of a representative (or agent) in the United States who will handle matters connected with isotope shipments. (Such representative may be a diplomatic official, a commercial concern, or any other person or corporation selected by the foreign government. The representative should be authorized to maintain liaison with the

1184898

U. S. Atomic Energy Commission and to complete financial and shipping arrangements, such as payments for materials, deposits for shipping containers, and arrangements for transportation);

2. That the representative is authorized to certify in behalf of the government to the accuracy of the information set forth in each application for isotopes;

3. That the government understands that there are special health and safety hazards arising out of the possession, handling, or use of radioisotopes, and that such hazards require special protective measures;

4. That the government agrees that neither the United States Government, nor any United States distributing agent, shall be responsible for injury or damage caused by, or in the application of, any radioisotope delivered.

CERTIFICATE. Each application for export of isotopes should contain the following statement:

The undersigned, in behalf of the government he represents, agrees to the following statement:

1. To furnish the U. S. Atomic Energy Commission upon request, or in any event at intervals of not more than one year, results of progress obtained with the use of isotopes procured from its facilities;

2. That the materials will not be used in a manner other than described in the request;

3. To facilitate exchange of information and visits relative to work with isotopes between qualified scientists in accordance with normal scientific practice.

1184899

AUTHORIZATION. When the Commission determines that the requested material or service can be furnished, an "Authorization for Procurement of Isotope for Export," Form AEC- , will be issued to the designated representative.

PROCUREMENT. Send purchase order to the distributor or supplier after Form AEC- has been received. Note: The Isotopes Division issues authorizations but does not ship or sell isotopes. Make arrangements for purchase, shipment, and payment directly with distributors and suppliers.

TRANSPORTATION. Shipping arrangements should be made with the supplier. Shipment from Atomic Energy Commission facilities will be sent to any point within the continental limits of the United States, shipping charges collect. Customs clearance and transportation outside the continental limits of the United States should be arranged by the designated representative.

EXPORT LICENSE. A Department of Commerce license is also required for export of isotopes. An "Application for Export License," Form IT-419, should be submitted to:

Bureau of Foreign Commerce
U. S. Department of Commerce
Washington 25, D. C.

Attention: Chemicals Division

An export license covering a particular shipment may be obtained or the Department of Commerce may issue to the official representative a blanket license, good for one year, covering all items on the United States export list, as authorized by the AEC.

1184900

MATERIALS AND SERVICES. Radioisotopes and irradiation services subject to Commission regulations may be obtained from Canada and the United Kingdom.

Write to suppliers for catalogs and price lists of materials and services.

APPLICATION PROCEDURE. Complete "Application for Radioisotope Procurement," Form AEC-313, and mail to the Isotopes Division. Indicate under Item 8 that the radioisotope will be procured from Canada or the United Kingdom. "Authorization for Radioisotope Procurement," Form AEC-374, will be issued to an applicant whose application is approved. NOTE: Persons holding General Authorizations may obtain radioisotopes from Canada or United Kingdom by furnishing a copy of the general authorization without submitting another Form AEC-313.

PROCUREMENT FROM CANADA. A set of the Canadian application, Form AECL-247, and U. S. authorization are required by the Canadian supplier before final action can be taken by the Canadians. (If the applicant desires, he may forward the Canadian application to the Isotopes Division at the same time as he submits the Form AEC-313. The Isotopes Division may then send the Canadian application and valid authorization to the appropriate Canadian office.) Arrangements for shipment and payment should be made directly with the supplier.

PROCUREMENT FROM THE UNITED KINGDOM. A person holding a valid Form AEC-374, may place his order directly with the British supplier. A copy of Form AEC-374 should be submitted to the British supplier with the order for the isotope. All arrangements for shipment and payment should be made directly with the supplier.

1184901

V. RADIOLOGICAL SAFETY

"The Commission shall not distribute any by-product materials to any applicant, and shall recall any distributed materials from any applicant, who is not equipped to observe or who fails to observe such safety standards to protect health as may be established by the Commission or who uses such materials in violation of law or regulation of the Commission or in a manner other than as disclosed in the application therefor." From the Atomic Energy Act.

RADIOLOGICAL-SAFETY CONTROL MEASURES EXERCISED BY THE COMMISSION. In discharging its responsibility for promoting safe use of radioisotopes the Commission exercises the following controls and measures:

(1) Control by Allocation. Radioisotopes may be procured only upon authorization of the Commission. See Section II for details of the application procedure.

(2) Radiological Safety Education. Through correspondence, on-the-job visits, and various publications, the Commission advises and assists in the development of safe radiological procedures and programs. See Section VI for details of the Information Program.

(3) Visitation by Radiological Safety Branch. Technical specialists of the Radiological Safety Branch, Isotopes Division, routinely visit radioisotope users to assist in radiation protection problems and determine if radioisotopes are being used in a safe manner. Facilities and procedures for maintaining radiological safety are observed and evaluated including such items as: handling equipment (tongs, pipettes, devices), laboratory facilities, shielding, ventilation (including hoods,

1184902

closed systems), storage facilities, radioisotope handling procedures, film badges, dosimeters, pocket chambers, other monitoring instruments, radiological monitoring procedures, warning signs, waste disposal, and records.

(Consultation on feasibility of specific isotope applications is not handled by the Isotopes Division inasmuch as this service is available from a number of commercial firms and private consultants.)

RADIOLOGICAL SAFETY INSTRUCTIONS. Instructions issued by the Commission for safe use of radioisotopes are based on recommendation of the National Committee on Radiation Protection, experience gained in Commission laboratories, and on the job visits to radioisotope users. Recommendations of the NCRP are published by the National Bureau of Standards in a series of Handbooks (see Section VI for list of Handbooks and how to obtain them.)

BASIC PRINCIPLES OF RADIATION CONTROL. Radiation safety is maintained by shielding, by distance from the radioactive source, by time limits of exposure or by a combination of the three. Radiation injury may result from (a) external exposure or (b) internal exposure. Excessive external exposure may result from inadequate shielding, or failure to observe time-distance limitations by working too closely to a radiation source or remaining within a radiation field for an excessive length of time. Internal exposure may result from ingestion or inhalation of radioactive materials or introduction of such substances into the body through open wounds or breaks in the skin.

1184903

Methods of Radiation Control

A radioisotope user should have physical facilities, handling equipment, storage containers, and survey and monitoring instruments suitable and adequate for the type and amount of radioisotope(s) he is using. Operating procedures, including handling techniques, waste disposal methods, and radiation survey and monitoring procedures should be designed to assure minimum radiation exposure.

INHALATION AND INGESTION. Protection from inhalation or ingestion of radioactive materials is accomplished by (1) controlled ventilation to keep dusts, gases, and vapors out of the air, (2) rigorous housekeeping to control radioactive contamination, and (3) avoiding opportunities for direct ingestion (such as by use of remote pipettor).

INSTRUMENTATION. All users of radioisotopes distributed by the Commission are required to have adequate instrumentation for (1) measurement of activity, (2) monitoring radiation levels, and (3) personnel protection. Choice of instrument depends on the type of radiation and the level of activity. Refer to National Bureau of Standards Handbook 51 "Radiological Monitoring Methods and Instruments." Exceptional cases that do not require instrumentation should be explained in an applica-

PERSONNEL MONITORING DEVICES. The use of film badges, pocket dosimeters, and similar personnel monitoring devices, is desirable whenever the type or quantity of radioactive material involved makes their use practical. Film badges are particularly desirable in the case of field radiography using radioisotopes. In the case of film badges, it is essential that control films be processed together with the exposed film, and that they be compared by means of a densitometer. Film badge service and pocket dosimeters are available from several commercial firms.

1184904

~~they be compared by means of a densitometer. Film badge service is available from several commercial firms.~~

DISPOSAL OF WASTE RADIOISOTOPES. Two general methods of controlling wastes are: (1) concentration and storage and (2) dilution and dispersal. Disposal may be accomplished in the following ways: (1) gaseous and airborne materials may be controlled by filtration and/or dilution with air; (2) short-lived radioactive liquids may be controlled by storing them until they decay to a safe level and/or by dilution with water, (3) long-lived radioactive liquids may be controlled by concentration or evaporation to a solid state and either stored or buried, and (4) solid radioactive and contaminated materials may be disposed of by burial in soil or disposed in the ocean under controlled conditions. (Refer to National Bureau of Standards Handbook 49 "Recommendations for Waste Disposal of Phosphorus 32 and Iodine 131 for Medical Users," Handbook 53 "Recommendations for the Disposal of Carbon 14 Wastes," and a handbook now in press regarding disposal of radioactive wastes in the ocean.)

SPECIAL DISPOSAL SERVICE. Upon arrangement with the facility involved, reactor-produced radioisotopes, and materials and equipment which have become contaminated from the use of reactor-produced isotopes, may be returned for disposal to the following Commission facilities: The Radiation Laboratory, University of California, Berkeley, California, will receive radiomaterials from users in the San Francisco Bay Area.

Oak Ridge National Laboratory, Carbide and Carbon Chemicals Company, Oak Ridge, Tennessee, will accept radiomaterials from users in all sections of the country.

In addition, authorizations have been issued for operating of commercial disposal services.

Arrangements for disposal service should be made directly with the AEC receiving facility or an authorized commercial disposal firm.

Caution Signs

Persons using radioisotopes are instructed to mark areas where radioisotopes are used or stored with an appropriate caution sign posted in a conspicuous location. A sign similar to the one reproduced below would be satisfactory. Ordinarily the background is yellow and the printing magenta. A caution sign is not required for hospital rooms or other areas where radiation patients are placed or for areas temporarily used for radioisotopes under constant supervision of a competent person.

1184906

VI. TECHNICAL SERVICES

Information Program

THE FIVE-FOLD PROGRAM sponsored by the Commission for developing wider use of isotopes is as follows:

1. Provide references on isotope uses.

2. Provide information on isotopic materials and procurement policies and procedures.

3. Provide information on radiological safety in the storage, use and disposal of radioisotopes.

4. Assist in developing and presenting radioisotope technique training courses and in the production of training films and other visual aids.

5. Encourage industrial and commercial participation.

To effect this program, the Isotopes Division publishes, in addition to this Manual, announcements of changes in policies and procedures; lends training films and slide illustrations; maintains an extensive bibliographical index.

MAILING LIST. Official distribution of informational material from the Isotopes Division is limited to a departmental and institutional basis; that is, one copy of each publication is forwarded to each authorized applicant plus an additional copy for each using department. Official distribution is further limited to "current users" or to those departments and institutions which have received Commission authorization to procure stable or radioactive isotopes within the preceding 18-month period. The official distribution list is revised each June.

1184907

NBS HANDBOOKS. The National Bureau of Standards Handbooks listed below may be purchased from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. The Handbooks are useful sources of information of a radiological-safety nature; they contain recommendations of the National Committee on Radiation Protection.

Handbook 27 - Safe Handling of Radioactive Luminous Compounds - $0.10

Handbook 41 - Medical X-Ray Protection up to Two Million Volts - $0.20

Handbook 32 - Safe Handling of Radioactive Isotopes - $0.15

Handbook 47 - Recommendations of the International Commission on Radiological Protection - $0.15

Handbook 48 - Control and Removal of Radioactive Contamination in Laboratories - $0.15

Handbook 49 - Recommendations for Waste Disposal of Phosphorus 32 and Iodine 131 for Medical Users - $0.10

Handbook 50 - X-Ray Protection Design - $0.15

Handbook 51 - Radiological Monitoring Methods and Instruments - $0.15

Handbook 52 - Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water - $0.20

Handbook 53 - Recommendations for the Disposal of Carbon 14 Wastes - $0.15

Handbook 56 - Safe Handling of Cadavers Containing Radioactive Isotopes - $0.15

TRAINING FILMS. The Army Signal Corps, with the technical assistance of the Atomic Energy Commission and its contractors, has produced for the Medical Illustration Service of the Armed Forces Institute of Pathology,

a series of training films entitled, "The Radioisotope." The films that have been completed are: (1) Fundamentals of Radioactivity, (2) Properties of Radiation, (3) Practical Procedures of Measurement, (4) Methodology, (5) Principles of Radiological Safety, (6) Practice of Radiological Safety, (12) Agriculture and Research, and (13) General Sciences. Films in the series that have not yet been produced are: (7) Biological Effects of Radiation, (8) Medical Research, (9) Medical Diagnosis, (10) Medical Therapy, and (11) Industry and Engineering.

The films are designed to instruct professional scientific personnel in the underlying principles and practical considerations governing the handling and use of radioisotopes. As training films they are intended for an audience of high professional, technical and educational level.

If additional films of the series become available, announcement will be made by the Isotopes Division. Copies will be available for loan from the Isotopes Division and from the various Army Headquarters' Central Film Libraries.

A "Guide to the Training Film Series" is available from the Isotopes Division. The Guide provides general information on objectives, audience level, technical director, background, purpose of the films, animation, fact density, how to get the most out of the films, organization of the film series, and includes a brief synopsis of each film in the series.

SLIDE ILLUSTRATIONS. The Isotopes Division has prepared, primarily for use as lantern slides, an extensive series of line-drawing illustrations which are valuable aids for educators, lecturers, and students. The subject

1184909

matter includes isotope production, isotope characteristics, isotope distribution, and isotope applications in biology, medical research, diagnosis and therapy, agriculture, chemistry, physics and industry. Copies of the illustrations in the form of 8" x 10" glossy prints are available on loan from the Isotopes Division for reproduction purposes.

BIBLIOGRAPHIES. From time to time the Isotopes Division issues bibliographies giving references to published work done with isotopes procured through Commission facilities. These bibliographies are similar to those published in the reports, "Isotopes... A Three-Year Summary of U. S. Distribution," and "Isotopes... A Five-Year Summary of U. S. Distribution." The two published reports are for sale by the Superintendent of Documents, Government Printing Office, Washington 25, D. C., at 45¢ and $1.00, respectively.

ISOTOPICS - ANNOUNCEMENTS OF THE ISOTOPES DIVISION has been published on a quarterly basis, appearing in January, April, July, and October to inform isotope users on isotope procurement and authorization procedures, distribution policies, tracer techniques, methods for the safe handling and disposal of radiomaterials, isotope applications. It does not accept for publication material prepared outside AEC facilities. To date issues through Volume 4, No. 1 have been distributed.

ISOTOPICS is available for general distribution from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. The price is $1.00 per volume, or separate issues are available at $0.35 per copy.

1184910

OAK RIDGE INSTITUTE OF NUCLEAR STUDIES. Instruction in the handling and use of radioisotopes is currently available from the Special Training Division, Oak Ridge Institute of Nuclear Studies. The laboratory and lecture course offered by the Institute is the only one of its type currently open to the majority of professional and technical people seeking such training.

The four weeks basic training course offered by the Oak Ridge Institute covers fundamental concepts and techniques involved in handling and using radioactive materials. To determine whether this amount and type of training will qualify an individual to use radioisotopes, it is necessary to consider not only the nature of the proposed work, but also the amount of radiomaterial to be used and the circumstances under which the work will be carried out. In most instances, completion of such a course will qualify an investigator to use tracer levels of radioisotopes for research and development activities, provided the necessary laboratory facilities and instrumentation are available.

If the isotope is to be used under unusual circumstances, such as in a field experiment, or if the work involves some special hazard, it will usually be necessary for the investigator to have available, at least initially, the services or assistance of a more experienced user of isotopes.

A basic training course alone is not sufficient background to permit an investigator to use radioisotopes in medical studies involving humans. Such users must have clinical experience in the particular type of application to be made of the radioisotopes. To date special training of this type has been available only through participation in a group using radioisotopes for such purposes.

1184911

VII. ADVISORY COMMITTEES

The Commission's Advisory Committee on Isotope Distribution

An Advisory Committee on Isotope Distribution was set up in 1947 to aid the Commission in establishing new policies on the distribution of radioactive materials and to review existing policies from time to time. In general, the Committee reviews and makes recommendations on all matters pertaining to the Commission's isotope distribution program. On specific problems referred to it, the Committee functions as two subcommittees:

1. The Subcommittee on Human Applications, to advise on use of radioisotopes in human beings.

2. The Subcommittee on General Applications, to advise on use of radioisotopes in research, agriculture, industry and such other uses as may be developed.

On recommendation of the Advisory Committee, the Commission encourages every institution, which uses radioisotopes extensively, to form an isotope committee to supervise and control the use of radioisotopes within the institution and requires the formation of an institutional isotope committee to support an application for institutional medical uses or a General Authorization for research and development.

The organization and functions suggested below for institutional and local isotope committees follow the recommendations of the AEC Advisory Committee.

Suggestions Concerning Institutional Isotope Committees

FORMATION OF AN ISOTOPE COMMITTEE ON HUMAN USES. Membership of the Committee should include:

1184912

1. An internist.

2. A hematologist.

3. A therapeutic radiologist.

4. A pathologist.

5. An individual experienced in assay of radiomaterials and protection against ionizing radiations.

It is to be noted that one person may serve in more than one of the above capacities.

FORMATION OF AN ISOTOPE COMMITTEE ON GENERAL USES. The background and experience of members of this committee may be diverse. The membership may include:

1. A representative of the business office.

2. A radiological safety officer.

3. One or more persons with training and experience in the safe use of radioactive materials (radiochemist, radiobiologist, radiophysicist, etc.).

4, Other representatives as seem appropriate to the scope of the program (agronomists, physiologists, zoologists, etc.).

DUTIES OF THE COMMITTEE. Generally an Isotope Committee should have the following responsibilities:

1. Review, grant permission for, or disapprove the use of radioisotopes within the institution from the standpoint of radiological safety.

2. Prescribe special conditions as may be necessary (such as physical examinations, additional training, designation of limited area or location of use, disposal methods, etc.).

1184913

3. Receive reports from the radiological safety officer and review his records.

4. Recommend remedial action when an investigator fails to observe safety recommendations, rules, or regulations.

5. Keep a record of actions taken in approving the use of radioisotopes.

Suggestions Concerning Institutional Radiological Safety Officers

DUTIES. Responsibilities of this position should be assigned to a single individual, although specific duties may be delegated by him to one or several assistants. (See NBS Handbook 48, pages 2-3 for discussion of responsibilities.) The following are recommendations for specific duties:

1. Review all plans for the proposed use of radioisotopes from the standpoint of radiological safety and make appropriate recommendations to the experimenter and Institutional Isotope Committee.

2. Review all requisitions for radioisotope procurement to insure that a suitable storage area exists for the radioisotope shipment.

3. Survey incoming shipments of radioisotopes and supervise the storage and distribution of such shipments.

4. Require the posting of warning signs in areas in which radioisotopes are used or stored.

5. Supply personnel monitoring devices (film badges, pocket meters, dosimeters, etc.) and give instructions in their use.

6. Determine exposure potentials under working conditions and recommended time limits of personnel exposure and minimum working distances.

1184914

7. Survey storage and working areas as frequently as necessary.

8. Supervise decontamination of all spills or personnel contamination.

9. Supervise the disposal of radioactive waste.

10. Calibrate and arrange for prompt repair of survey instruments.

11. Supervise the maintenance of complete records of personnel exposure; of reciept, storage, transfer and disposal of radioisotopes; and of unusual incidents such as spills or the loss of radioactive materials.

12. Act in an advisory capacity on the design or alteration of radioisotope laboratories or handling facilities.

Records

IT IS IMPORTANT to stress the need for complete records of personnel exposure, and of the receipt, storage, use, transfer, and disposal of radioisotopes. Any unusual situation should also be fully recorded; e.g., an incident of overexposure and remedial actions taken.

1184915

July 5, 1946

Minutes of Meeting June 28, 1946, and suggested Radioisotope Order, Production and Shipping Procedures

Present: J. R. Lum, J. R. Coe, M. Leverett, R. C. Thumser, C. J. Koenig, Prescott Sandidge

1. Mr. Coe suggested that the present isotope committee should be dissolved, to be replaced by an advisory board to be appointed by Mr. Wigner. This board will determine broad policy in regard to allocation of Clinton Laboratories' facilities for isotope manufacturing so that the research program will not be hindered. It will deal with the Manhattan District Isotope Branch on all non-routine matters of technical nature, for example, coordination of work performed at other locations, with that at Clinton Laboratories. All inquiries from the District Isotope Branch will be addressed to the Chairman of this Committee.

2. A production committee, consisting of Logan Emlet as Production Superintendent, Merrill Tyson of Operations, W. E. Cohn of the Chemistry Division, Walton Rodger of the Technical Division, and James Cox, acting as Executive Chairman of the Committee, will devote full time to the Isotope Program. Each month it will prepare forecasts of the production for the coming month for the guidance of the Isotope Branch of the District.

3. The physical handling of an isotope order and delivery of the product falls into the following departmentalisation:

a. Order Handling
b. Production
c. Shipment
d. Accounting

4. Order Handling -

The District Isotope Branch will handle all preliminary inquiries and contacts with the customers. This may involve frequent contacts with Mr. Cohn and others at Clinton Laboratories, but all definite commitments will be made by us through Mr. Cox. All requests for isotopes will be received by the District which will determine whether the order is acceptable or not. If such request is approved, the requestor will be notified by the District to issue a purchase order to Monsanto Chemical Company, Clinton Laboratories. A copy of this approval form will be routed through the office of Lt. Col. Leber, to Mr. Cox. Upon receipt of the customer's purchase order and agreement form it will be matched with the District approval and if in order, Mr. Cox will notify the proper member of the Production Committee to begin work on filling the order. Mr. Cox will acknowledge the cutomer's order on receipt, supply approximate shipping date, and any other information deemed pertinent.

118491b

5. Production -

From a production standpoint there are three classes of isotopes:

a) Those handled only by the Pile Department and requiring no chemical separation; such orders will be routed by Mr. Cox to Mr. Tyson.

b) Those on which a standardized separation process has been developed by the Technical Division; such orders will be routed by Mr. Cox to Mr. Rodger.

c) Specialty items which require chemical separation by the Chemistry Section; such orders will be routed to Mr. Cohn.

Mr. Cox will classify all orders according to the above and will issue a production order to either the Pile Department, Technical Operations or Chemistry Section. As soon as production has been completed the department will notify Mr. Cox in writing, but will hold the material pending receipt of his instructions.

6. Shipment -

Upon receipt of this information, Mr. Cox will issue a Shipping Memorandum in 4 copies and distribute as follows:

No. 1 and No. 2 Copies to Isotope Shipping Department.

No. 3 Copy to department having produced the material.

No. 4 Copy to Mr. Cox's file.

As soon as the producing department receives the No. 3 copy of the Shipping Memorandum the material will be moved to the Isotope Shipping Department, which will be under the direction of the Plant Manager, where it will be packaged for shipment and monitored by Health-Physics. After the material has been turned over to the carrier, the No. 2 copy of the Shipping Memorandum will be filled in and signed by a responsible member of the Isotope Shipping Department and forwarded to the Accounting Department with a copy of the bill of lading. Under no circumstances will the Isotope Shipping Department release a shipment until instructed to do so by shipping memorandum.

7. Accounting -

The Shipping Memorandum will be a pre-numbered form, which feature will enable the Accounting Department to make certain that every shipment is billed to the customer. Upon receipt of a properly executed No. 2 copy of Shipping Memorandum, together with a copy of the bill of lading, the Accounting Department will issue an invoice and charge the customer's account for the amount involved. The amount of funds so collected will be handled as a miscellaneous receipt and deducted from reimbursement vouchers submitted to the Government.

1184917

Separate records will be maintained for isotope containers, and each container will be assigned an identification number. The invoice amount will include deposit on the container and this amount will be refunded to the customer as soon as the Accounting Department is in receipt of its regular copy of the receiving report, indicating that the container has been returned prepaid, in good condition. Returned containers will be processed through normal Receiving Department channels.

Prescott Sandidge
Assistant Executive Director

CJK:ph

cc: J. H. Lum
J. R. Coe
M. Leverett
R. C. Thumser
C. J. Koenig
Prescott Sandidge
E. P. Wigner
S. J. Murphy
L. Smalet
M. H. Tyson
W. E. Cohn
W. A. Rodger
J. Cox

1184918

24 May 1946

Dr. C. A. Thomas
Monsanto Chemical Co.,
St. Louis, Missouri

Dear Dr. Thomas:

The passage of legislation has been so long delayed that in the national interest it is desired to distribute such radioisotopes as to non-project users as can be made available. At some later date distribution of stable isotopes may be initiated. To establish policies and procedures an "Interim Advisory Committee on Isotope Distribution," which was formed from nominations submitted to us by the National Academy of Sciences, has recommended policies and procedures for this distribution. A copy of their recommendations dated May1, is attached.

For a successful program at this time certain of the isotopes must be produced at Hanford and at other installations of the District.

Preliminary informal conferences have been held between representatives of the Clinton Laboratories and of the Research Division of the District Office at Oak Ridge. It is desired to make formal plans and procedures for effecting our isotope distribution program.

It is desired that Monsanto set up at Clinton Laboratories the organization and facilities to effectuate this program. Involved therein is the planning and production, utilizing all sources in the District that can be made available without interruption to higher priority work; the processing, business and shipping facilities to process all isotopes and irradiated materials including those produced at other District installations; and the distribution in accordance with instructions from the District.

To effectuate the above it is requested that plans and procedures be worked out directly with the Chief of the Research Division of the District at Oak Ridge, or such representatives as he designates.

It is desired to announce the program by means of a press conference to be held at Oak Ridge about June 4, 1946. Although price lists, amounts in which isotopes will be available, and system of allocation may not be announced in detail at that time it is

(7)

1184919

desirable that such information be known to us prior to that time. Accordingly, it is requested that costs and approximate units in which isotopes will be distributed be estimated by Kenneth and furnished to the Chief, Research Division with a copy thereof to me.

In estimating the costs the true costs should be determined utilizing standard business procedure, except that plant rentals of major items of equipment such as piles, or existing laboratories should not be included. Operating costs of major items, and special equipment costs, however, should be properly apportioned.

I believe the distribution of isotopes to non-project users is of great value to the nation and I trust that suitable arrangements can be made to carry out the program.

Sincerely yours,

K. D. NICHOLS
Brigadier General, U. S. A.
District Engineer

1184920

D R A F T

Dr. Paul B. Dunbar, Commissioner
Food and Drug Administration
Washington 25, D. C.

Dear Dr. Dunbar:

At a recent meeting between representatives of the Atomic Energy Commission and representatives of the Federal Food and Drug Administration several problems and questions were discussed as they pertain to the AEC radioisotopes distribution program and the Federal Food, Drug, and Cosmetic Act. Attached is a memorandum prepared by Dr. S. Allan Lough of the AEC Isotopes Division summarizing the discussion at this meeting.

The AEC, through the Isotopes Division and contractors operating AEC-owned facilities, carries on a broad program for the production, allocation, and distribution of radioactive materials under authority contained in the Atomic Energy Act of 1946. This Act directs the AEC to foster the development of radioactive materials and to distribute such materials for purposes of research and development in certain fields, as well as for use in medical therapy, industry, and for such other useful applications as may be developed. By statute the AEC has the duty to provide for such standards with respect to the use of these materials as may be necessary to protect health and minimize hazards to life and property. This function is accomplished primarily through review of the applicant's

1184921

qualifications, the method of use, and purpose for which radioisotopes are requested, prior to authorizing procurement. Recently the AEC has published in the Federal Register rules governing the procurement and possession of radioisotopes, and studies are now being made to determine appropriate health and safety standards to be published as a part of these regulations.

As explained during the meeting with representatives of the Food and Drug Administration, the AEC Isotopes Division previously has known the intended use of all radioisotopes allocated through the AEC's program, but due to recent changes in procedures neither the Isotopes Division nor the AEC distributor will be informed of the intended uses of "exempt quantities" of radioisotopes procured under the AEC regulations. In addition the inauguration of General Authorizations to procure radioisotopes will mean that AEC distributors will not know the intended use of radioisotopes ordered from them under such authorizations. This may also be true in the case of other suppliers filling orders from customers based on general authorizations granted by the AEC or contained in the regulations.

We understand the position of the Food and Drug Administration to be that radioactive materials, when administered to human beings or animals, are "new drugs" within the meaning of the Federal

1184922

Food, Drug and Cosmetic Act and, as such, may not be shipped until the shipper has an appropriate certificate as required by regulations issued under Section 505 (i) of the Food and Drug Act. While AEC distributors have heretofore obtained such certificates on materials allocated for experimental drug use, the changes in procedure referred to above will eliminate the basis on which to determine that such certificates would be proper on shipments of "exempt quantities" or shipments made pursuant to general authorizations.

Also discussed at the meeting were the applications the Isotopes Division has received in recent months from persons requesting radioisotopes to be used in, or in connection with, the processing of food. These applications involve not only the AEC's functions as the licensing agency for radioisotopes allocated under the Atomic Energy Act, but also its role as manufacturer and distributor of such materials through its contractors operating AEC-owned facilities. An important aspect of the problem presented by these applications is the possibility that the AEC may approve as safe and distribute radioisotopes for particular uses which, later, the Food and Drug Administration might determine were in violation of the Federal Food, Drug and Cosmetic Act.

1184923

Additional discussion of the matters presented above is contained in the attachments. We shall appreciate your consideration and suggestions how the AEC and the Food and Drug Administration may handle the specific cases mentioned as well as future situations which undoubtedly will arise. In carrying on our radioisotopes distribution program it is our desire to make the procedures followed in submitting applications for, or obtaining, radioisotopes as simple as possible. While we believe the AEC should not undertake to interpret or apply the Food and Drug Act with respect to proposed uses of radioisotopes, we are satisfied there is need for close coordination with the Food and Drug Administration in the conduct of our program. Although users of radioisotopes are advised through the AEC's regulations that AEC approval does not constitute compliance with other Federal or State laws, it would be an unfortunate situation if admittedly safe uses of radioisotopes, for example, placed the user in jeopardy under the Food and Drug Act.

Enclosed are copies of the AEC Isotopes Catalog and Price List No. 4, March 1951, which outlines the present procedure for procuring radioisotopes (pp. 44-50), and contains the AEC published regulations pertaining to these procedures (pp. 67-71).

1184924

In Attachment 3, you will find a discussion which leads up to the suggestion that an ad hoc committee be formed, the membership of which would be composed of representatives of the AEC and the Food and Drug Administration. This committee could be of considerable assistance in connection with review of applications for radioisotopes involving uses of interest to the Food and Drug Administration. It might also make a study of the general relationship of the functions of the Food and Drug Administration and the AEC which pertain to the use of radioisotopes in those areas of mutual interest to both agencies.

We are most anxious to effect a satisfactory arrangement with the Food and Drug Administration with respect to these matters, and will be happy to meet with you or your representatives for such further discussions as may be desirable to develop our respective views and interests in the radioisotopes distribution program.

Very truly yours,

M. W. Boyer
General Manager

Enclosures:
1. Attachment 1, Memorandum to Files, Conference of April 25, 1951
2. Attachment 2, Use of Radioisotopes as "New Drugs"
3. Attachment 3, Use of Radioisotopes in Food Processing and Food Sterilization
4. Isotopes, Catalog and Price List No. 4, March 1951
5. Forms AEC-465, AEC-313, AEC-374

1184925

ATTACHMENT 2

Use of Radioisotopes As "New Drugs"

Since the initiation of the radioisotope distribution program, applicants requesting radioisotopes for experimental use as drugs have executed certificates of compliance specified under Section 505 (i) of the Food and Drug Act and have submitted such certificates to AEC distributors. Until the adoption of a new procedure for distributing radioisotopes the Isotopes Division obtained information as to the intended uses of all radioisotopes distributed through the AEC, and where experimental drug use was stated it advised the applicant to submit a Section 505 (i) certificate with his purchase order for radioisotopes.

This procedure was adopted by the Manhattan District after correspondence from the Food and Drug Administration advised that any materials containing radioisotopes and intended for use in humans or animals were "new drugs" within the meaning of the Food and Drug Act. Although no determination was made that Manhattan District allocations of radioisotopes through its contractors were legally subject to compliance to Section 505 (i), this requirement of certificates under that Section was accepted as a matter of policy.

This procedure has been carried over by the AEC and has been followed as accepted practice until the present time. With the publication of the recent regulations governing radioisotope distribution, two situations have

arisen wherein the supplier--whether it be an AEC-owned facility or other person--will not be aware of the intended use of radioisotopes at the time the customer places his order for such materials. These situations arise because:

1. Certain small quantities of radioisotopes have been exempted from the requirements of submitting an application to the Isotopes Division and obtaining prior approval from that Division before obtaining the materials.
2. The Isotopes Division now approves general authorizations to procure radioisotopes and these authorizations may be used to obtain any isotope in any amount, at such times as the approved applicant desires.

In the first situation neither the Isotopes Division nor the supplier will receive any information regarding the intended use of the materials since AEC regulations now permit the procurement, possession, and use of "exempt quantities" of radioisotopes (10 C.F.R. 30.13, 30.71). In the second case, the Isotopes Division will learn at the time application for a general authorization is made that the applicant desires at some time to obtain radioisotopes for experimental use as drugs. However, the supplier will have no method of determining the intended use of radioisotopes procured on a particular purchase order unless the purchaser volunteers this information.

Exempt Quantities

A considerable number of worthwhile biological experiments can be performed by use of "exempt quantities" of radioisotopes. For example, by using the best counting technique, one could measure the iodine up-take of the thyroid in humans by using 10 microcuries of Iodine 131. Thus the administration of

this "exempt quantity" of radioiodine, in either humans or animals, would constitute the use of a "new drug" within the definitions of the Food and Drug Act.

In distributing "exempt quantities" of radioiodine, however, the AEC distributor or other supplier is acting pursuant to the regulations referred to above. Moreover, such "exempt quantities" of radioiodine, as well as other radioisotopes, may be used for purposes other than as drugs--and often are. Without knowledge of the intended use of the materials therefore, in order to assure compliance with the Food and Drug Administration's regulations under Section 505 (i) of the Food and Drug Act, it would be necessary for the supplier to (a) refuse an order unless the purchaser furnishes a certificate that no drug use is intended or (b) require a Section 505 (i) certificate on every purchase order for an "exempt quantity" of radioisotopes.

While no opinion is expressed as to the applicability of the Food and Drug Act to persons receiving or transferring "exempt quantities" of radioisotopes from AEC distributors, it is our intention at this time not to require a Section 505 (i) certificate or other information of proposed use from customers applying to AEC distributors for "exempt quantities" of radioisotopes. This constitutes a departure from the procedure previously followed and raises for consideration what, if any, conflicts may result as concern the Food and Drug Administration.

Since the definition of new drugs as used in the Food and Drug Act appears to turn on the intended use of an article--i.e., in humans or animals--the shipment of radioisotopes where intended use is not known by the shipper may raise legal issues generally as to the applicability of the Food and Drug Act. Radioisotopes would not appear to be "new drugs", per se, as they may be used for many purposes.

In addition, the fact that a shipper originally procures radioisotopes as "exempt quantities" from the AEC distributor without submitting a Section 505 (i) certificate may now lead him to conclude he is free to make shipments without obtaining such certificates from his customers. (Note: Both the AEC regulations and AEC Form 374 contain statements that radioisotopes procured from or on AEC approval may be subject to other federal or state laws.)

On applications submitted to the Isotopes Division requesting a specific authorization to procure radioisotopes for experimental use as drugs we propose to continue, as a matter of policy, the practice of requesting the approved applicant to furnish a certificate as required by Section 505 (i) when the materials are procured from an AEC distributor. We propose also to continue the notice presently contained in the Isotopes Catalog which cautions users that such certificates may be required when materials are to be used for experimental drug purposes. Since the AEC distributor will not require such certificates for shipments of "exempt quantities", however, it would be desirable if the Food and Drug Administration would concur that other suppliers need not require these certificates when shipping "exempt quantities" without actual knowledge of intended use.

1184929

General Authorizations

The general authorization plan for procurement of radioisotopes is outlined on pages 44-46 of the AEC Isotopes Catalog and Price List No. 4 (attached). Under this plan a holder of a general authorization is permitted to procure from any supplier (AEC distributor or other person) any available form or quantity of radioisotopes distributed on the authorization of the AEC. General authorizations may be issued for "research and development activities" in the medical and biological field, and also may be issued to industrial concerns which make products for the sale to the public. General authorizations are not now granted to obtain radioisotopes for use in human beings, but those permitting "research and development activities" may involve the use of radioisotopes for experimental work in drugs.

General authorizations for "research and development activities", in most instances, will be requested by and granted to large institutions in which many different investigators will employ radioisotopes. Some of the investigations conducted may be in the medical and biological fields and may involve the use of radioisotopes as drugs. While the Isotopes Division will be advised of intended use as drugs at the time the application for a general authorization is submitted, neither that Division nor the AEC distributor will be aware that a particular purchase order for radioisotopes will be for such use. In fact, it is quite possible that one purchase order for radioisotopes will cover the requirements of several investigators only one of whom may be using radioisotopes for experimental work in drugs.

1184930

The same situation may be true with respect to suppliers other than AEC distributors who are filling radioisotope orders for large institutions.

Basically, the question involved is whether radioisotopes, per se, are or should be classified as "new drugs" within the meaning of the Food and Drug Act. If the fact that a shipper is not aware of the intended use of radioisotopes at the time of shipment eliminates the necessity of obtaining a Section 505 (i) certificate, the situation brought about by the adoption of the general authorization plan will cause no problems. However, if radioisotopes are considered "new drugs" subject to the Food and Drug Act under all circumstances, the question of obtaining these certificates becomes important. We see no objection to obtaining such certificates when in fact the intended use of radioisotopes is known and is for experimental work as drugs. As pointed out above, however, radioisotopes are also distributed for many other uses and it would appear to be an unwarranted requirement for the AEC distributor to insist upon evidence of the intended use when a general authorization has been granted by the Isotopes Division, or other permission is granted by that Division to obtain radioisotopes without disclosure of intended use.

If, from the standpoint of the Food and Drug Administration, it would be desirable to obtain certificates covering shipments of radioisotopes under an AEC general authorization, it would be feasible to follow this procedure: require an approved applicant to submit a Section 505 (i) certificate with his first order placed with the AEC distributor under a general authorization permitting procurement for experimental drug use and permit that

certificate to cover all orders thereafter placed with the distributor regardless of how many persons at the institutions perform "new drug" investigations. This procedure probably will require some revision of the wording of the certificate, but would enable the AEC to continue a policy of obtaining certificates without unduly burdening its distribution procedures. Such an arrangement probably would be helpful to secondary suppliers (i.e., those other than AEC distributors) filling orders for radioisotopes based on AEC general authorizations.

At the present time the majority of holders of general authorizations are institutions which, under the Food and Drug Administration regulations, may be exempt from the requirements of furnishing certificates because of their status as agencies of the United States or as agencies of states or municipalities whose official functions require investigations of new drugs by experts. The extent to which a holder of an AEC general authorization to procure radioisotopes for drug use is exempt from this requirement, however, involves an interpretation of the Food and Drug Administration's regulations and raises the question of who will determine the exempt status of an approved applicant? This would appear to be a function of the Food and Drug Administration, although to the extent AEC distributors continue to obtain Section 505 (i) certificates, it would be desirable to agree with the Food and Drug Administration upon a principle of applying the exemption from the certificate requirements. Where the government status of the applicant requesting radioisotopes for drug investigation is known, we should like to work on the following policy (a) that the application is sufficient evidence of "official function" and (b) AEC approval

1184932

of the application will suffice to establish that the investigator is an "expert". The adoption of this policy will enable the AEC distributor to make shipments of radioisotopes to federal or state agencies without requiring Section 505 (i) certificate and would avoid burdening the distributor with an obligation to determine the applicant's status under the Food and Drug Act regulations.

1184933

ATTACHMENT 3

Use of Radioisotopes in Food Processing and Food Sterilization

The Isotopes Division has received applications to allocate radioisotopes to be used in processing food, and also has received inquiries from other persons interested in obtaining radioisotopes for this purpose.

In one case the applicant requested a radioisotope to label a vitamin concentrate to be added to food. In this instance the addition of the radioisotope would be for the purpose of facilitating the mixing process and of reducing cost. By measuring the radioactive count of samples taken while mixing was being done, the applicant could readily determine the uniformity of the batch. Once the radioactivity was observed to be uniformly distributed, the mixing process could be stopped with assurance that the vitamin concentrate was also uniformly distributed.

In the case of one specific request which has come to the Isotopes Division, the expert consultants to whom the proposal was referred expressed the opinion that the program outlined by the applicant was entirely safe. The half-life of the radioisotope to be used is short, thus ensuring rapid disappearance of the source of ionizing radiation to a non-detectable level. Furthermore, the metabolic characteristics of the element involved are known. The element is absorbed from the gut in a very small amount; only 1×10^{-4} of the amount presented to the intestinal mucosa would be absorbed. Almost infinitesimal amounts of the element would be ingested by any one

animal, hence no possibility of chemical toxicity would exist. Because of rapid decay of the radioisotope, the normal period of time elapsing between completion of manufacture of the food and its ingestion by any animal would result in a product containing an almost undetectable amount of radioactive material.

At present various industrial concerns are also showing an interest in using radiations from radioisotopes for the purpose of sterilizing food.

Considerable experimental work has been done to show that bacteria, molds, including their spores, and even tissue enzymes are completely destroyed or functionally inactivated if the total radiation dose is high enough. The dose required is in the order of one million roentgens. Such a dose could be delivered to packaged or unpackaged foods under conditions which would allow sterilization in large batches. One interested group has expressed the belief that conditions could be established for the sterilization by gamma radiation of as much as a freight car load of bananas, for example. More developmental work is required, of course, to delineate the conditions under which industrial activity could be engaged in satisfactorily. No one has as yet determined precisely how many cans of tomatoes, or ripe olives, or other foodstuffs could be sterilized by radiation in one batch. But, of course, this kind of information awaits only actual tests, and satisfactory working conditions undoubtedly could be established.

In recent discussions with representatives of the Food and Drug Administration it would appear that the use of radioisotopes in food processing may involve

1184935

violation of the Food and Drug Act. It also appears that the use of radioisotopes to sterilize food would be prohibited by existing regulations requiring all food to be sterilized by heat, and such uses of radioisotopes might give rise to claims of adulteration or misbranding. Notwithstanding a determination by the AEC that a particular use of radioisotope will not be injurious to health, and notwithstanding that at the time of shipment or consumption no measurable amount of radioactivity remains in food, the Pure Food and Drug Act restricts the addition of foreign substances to foods.

The problem presented in these matters involves basically the possible conflict in the performance of statutory functions by two Federal Agencies, as such functions pertain to public health and safety. In allocating radioisotopes for uses authorized by the Atomic Energy Act, the Isotopes Division is concerned not only with health and safety of persons working with and handling radioisotopes, but also the public generally--in situations where the public may be effected. The existing AEC regulations and contemplated general health and safety standards are intended to provide for the protection of the general public.

In allocating radioisotopes for a particular use, the Isotopes Division is acting under the Atomic Energy Act and regulations issued pursuant thereto, and during authorized possession and use by an applicant, continues to exercise control over radioisotopes received from or through the AEC. In filling orders for radioisotopes, the AEC's distributors likewise act under authority of the Atomic Energy Act, regulations of the AEC, and other instructions from representatives of the AEC. Under present procedures,

1184936

large quantities of radioisotopes may not be obtained from Commission sources until the Isotopes Division, with assistance of its technical advisers, has evaluated the desirability of permitting radioisotopes to be used for the purposes requested and has determined to its satisfaction that the proposed use is safe, or that reasonable precautions and procedures will be followed to prevent possible health hazards. Where a proposed use involves medical treatment or possible exposure of the general public, the application for radioisotopes is submitted to and reviewed by advisory groups composed of outstanding doctors and persons with other professional and scientific knowledge in the radiation field.

In carrying on the radioisotope distribution program the fact that other Federal or other State laws may affect a particular proposed use of radioisotope by an applicant has been considered generally to be beyond the scope of consideration by the Isotopes Division in approving or disapproving an application. In certain fields, however, the AEC is aware of the interest of various State authorities in connection with radioisotopes being distributed in their States and to the fullest extent possible attempts to cooperate with such State officials. The AEC is also aware of the interest of the Food and Drug Administration in connection with possible uses of radioisotopes with food, drugs and cosmetics under the jurisdiction of that agency.

To consider each application for radioisotopes in terms of the impact of other Federal or State laws, in addition to creating administration burdens

1184937

on the AEC distribution program, also would involve the AEC in interpreting and applying statutes and regulations of other Federal, State or local authorities. Generally, we feel the enforcement of such laws as they concern users of radioisotopes should be left to the administrative or other enforcement procedures provided by such laws. At the same time the AEC is interested in fostering the development and expansion of worthwhile uses of radioisotopes, and where such uses possibly may be obstructed by the application of other laws, the AEC is interested in avoiding situations which may give rise to claims or other legal proceedings against persons receiving radioisotopes on AEC approval. In addition, the AEC does not desire to have its distributors making shipments of radioisotopes to be used by persons in a manner or for purposes prohibited by law, since transfers of radioisotopes by such distributors involve radioisotopes owned by the Commission and such transfers are made under authority and at the direction of the AEC.

Where AEC regulations do not require disclosure of intended use of radioisotopes obtained on AEC approval or from AEC sources, neither the Isotopes Division nor any AEC distributor will have information on which to determine the intended use and, consequently, will be unable to forecast possible violations of other Federal or State laws as they pertain to uses of radioisotopes.

Where radioisotopes are distributed or approved for procurement only after receipt and approval of an application disclosing the intended use, and such use is in the food, drug, or cosmetic fields, it is the AEC's desire

to work with the Food and Drug Administration to insure that approval or distribution of radioisotopes will not give rise to violations of the Food and Drug Act. To this end it is proposed that the AEC and the Food and Drug Administration designate representatives to meet and consider possible courses of action which may enable both agencies to carry on their representative functions without unnecessary restriction or interference to users of radioisotopes.

As a suggestion for consideration, the AEC proposes that for the present an ad hoc committee of the AEC and the Food and Drug Administration review applications submitted to the Isotopes Division for radioisotopes involving food, drug and cosmetic uses to (a) determine the interest of the Food and Drug Administration, and (b) recommend action on applications proposing a use which would be in violation of the Food and Drug Act although no health hazards are present. Such a committee might well be assigned a task of reviewing generally the relationship of the Food and Drug Administration and AEC functions in the development and use of radioisotopes for the purpose of recommending (a) amendments to AEC procedures and Food and Drug Administration regulations to facilitate wider uses of radioisotopes within limitations of the Atomic Energy Act and the Food and Drug Act, and (b) amendments to the Atomic Energy Act or the Food and Drug Act to eliminate duplication of functions, if any, or remove prohibitions on uses of radioisotopes where no health hazards are involved, and (c) appropriate legal control or standards in connection with the use of radioisotopes in foods, drugs or cosmetics as may appear to the committee to be in the National interest.

1184939

In reviewing specific applications of radioisotopes the committee should not be placed in the position of approving or disapproving an application, but merely should act as an advisory group to the Isotopes Division. The responsibility of allocating, distributing and approving applications to possess and use radioisotopes would remain entirely an AEC function.

1184940

Form AEC-445
(Rev. March 1, 1948)
B. B. 38-H032

UNITED STATES
ATOMIC ENERGY COMMISSION

CERTIFICATE OF COMPLIANCE WITH FEDERAL FOOD, DRUG, AND COSMETIC ACT

Regulations in effect under section 505(i) of the Federal Food, Drug, and Cosmetic Act provide that the shipper have the following statement on file prior to distribution of radioelements in interstate commerce if the material is intended for drug use or investigation, whether for experimental animals or human beings. Three copies of this statement must be signed and forwarded with your purchase order for radioactive materials.

This is to certify that the undersigned has adequate facilities for the investigation to be conducted by him as proposed in the "Application for Radioisotope Procurement," Form AEC-313, Serial No. ....., and that such drug will be used solely by him or under his direction for the investigation, unless and until an application becomes effective with respect to such drug under section 505 of the Federal Food, Drug, and Cosmetic Act.

Date .....

Signature .....

Title .....

Institution .....

U. S. GOVERNMENT PRINTING OFFICE 16—36734-2

1184941

1184942

Table of Contents

1184943

The section of the Trilinear Chart of Nuclear Species, which constitutes the cover of this catalog, has been reproduced with the permission of the author, Dr. William H Sullivan. The complete chart was published by John Wiley & Sons, Inc., New York, 1949.

1184944

At C. Oak Ridge, Tenn., 5-23-51—6,000—16-2434

Foreword

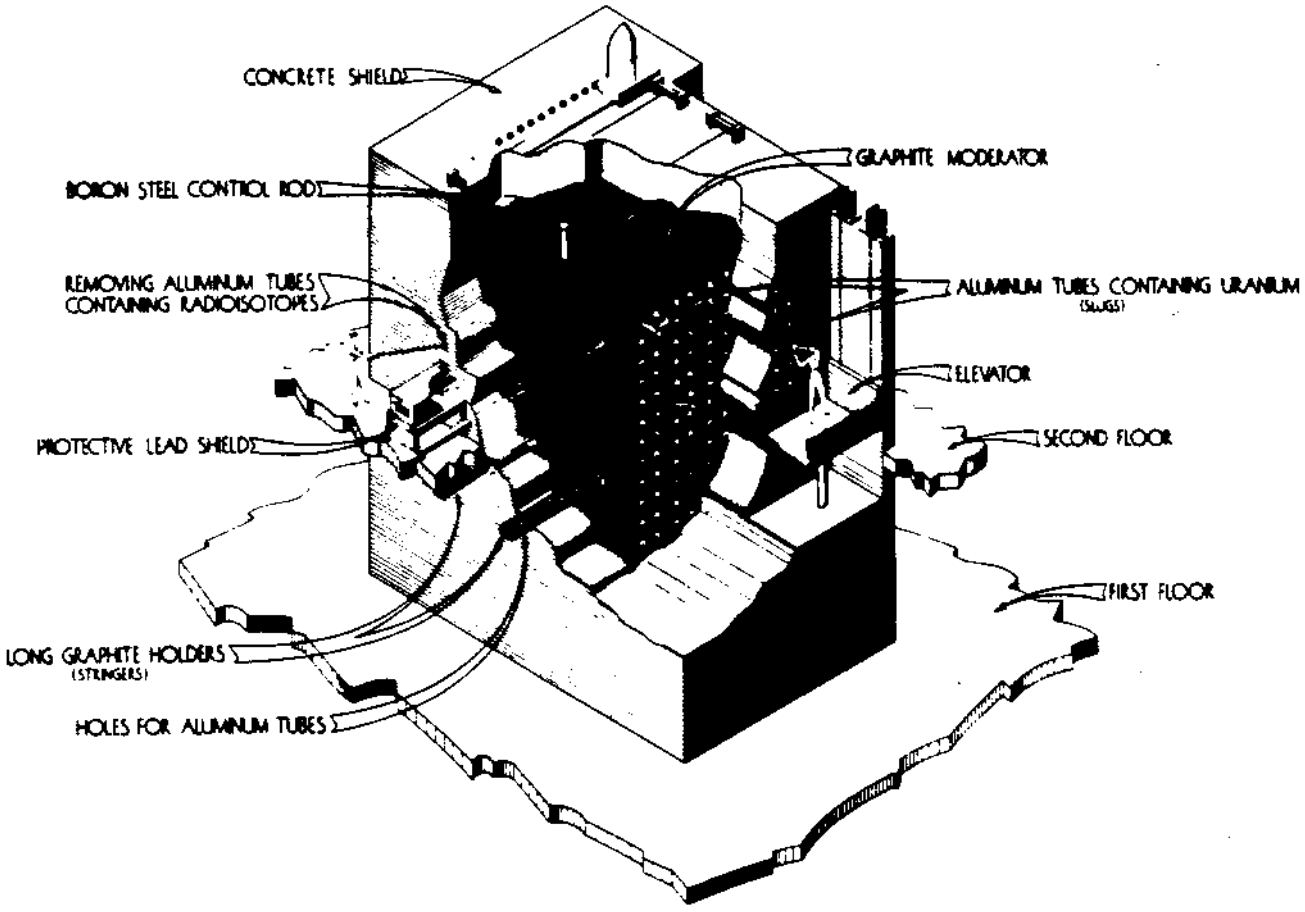
The U. S. Atomic Energy Commission is conducting a broad program for the distribution of radioactive and stable isotopes. This program is in keeping with the declared policy in the Atomic Energy Act of 1946 to direct the development and utilization of atomic energy toward "improving the public welfare, increasing the standard of living, strengthening free competition in private enterprise, and promoting world peace."

The Isotopes Division, Oak Ridge, Tenn., is responsible for conducting the Commission's program of authorizing the distribution of radioactive and stable isotopes, isotope-labeled compounds, and irradiation services. The program involves national distribution, both Commission and off-Commission, and international distribution of radioisotopes. The materials and services are offered for use in scientific research, medicine, industry, education, and other useful purposes as developed.

This catalog has been compiled by the Isotopes Division to furnish information and data concerning radioisotopes produced in a nuclear reactor, stable isotopes concentrated beyond normal abundance in Commission facilities, policies under which these materials are distributed domestically and abroad, and services, both technical and informational, available from Commission sources. The information must, in general, be brief; for more detailed discussions, reference should be made to the sources listed in the bibliography appearing at the back of this catalog. Individual inquiries should be addressed to

U. S. Atomic Energy Commission
Isotopes Division
Post Office Box E
Oak Ridge, Tenn.

1184945



Nuclear reactor—uranium pile.

1184946

1. Radioisotopes

ALPHABETICAL INDEX AND RADIATION DATA OF RADIOISOTOPES

The following alphabetical list gives the reactor-produced radioisotopes which may be procured through the U. S. Atomic Energy Commission. In columns 2, 3, and 4 are given radiation characteristics obtained from Nuclear Data, a report compiled and published by the National Bureau of Standards, Washington, D. C. (Circular 499). For additional information, reference should be made to this report. The last two columns give the reference numbers to catalog Tables 1 and 2, wherein are described the chemical forms and prices of the available radioisotopes.

Element and isotope	Half-life	Radiation, Mev		Catalog item No.	
		Beta	Gamma	Table 1 processed	Table 2 unprocessed
Antimony					
Sb 122	2.8d	1.36	0.568		51A,51B
		1.94			
Sb 124	60d	2.37	0.121	51B-P,51D-P	51A,51B
		1.6	0.60(95%)		
		1.0	0.65(5%)		
		0.65	0.714(24%)		
		0.5	1.70(70%)		
			2.06(6%)		
			~2.3(0.05%)		
Sb 125	2.7y	0.128(33%)	0.035	51C-P	51C
		0.299(49%)	0.110		
		0.616(18%)	0.175		
			0.425		
			0.465		
			0.601		
			0.637		
Argon					
A 37	34.1d	K	None	18-F	20
Arsenic					
As 76	26.8h	0.4(7%)	2.1		33A
		1.4(19%)	1.8		
		2.56(21%)	1.25		
			0.567		
		3.12(54%)			
			$2.3 < E_\gamma < 2.76$		
As 77	40h	0.7	None		33B,33C

1184947

Element and isotope	Half-life	Radiation, Mev		Catalog item No.	
		Beta	Gamma	Table 1 processed	Table 2 unprocessed
Barium					
Ba 131	12d	K	0.26		56
			0.5(strong)		
			~1.2(weak)		
Ba 137	2.60m	I.T.	0.669	55-F	
Ba 140	12.8d	0.48(40%)	0.540	56-F	
			0.306		
			0.160		
		1.022(60%)			
Bismuth					
Bi 210	5.0d	1.17	None		83
Bromine					
Br 82	36.0h	0.465	1.31		35
			1.04		
			0.82		
			0.77		
			0.69		
			0.61		
			0.55		
Cadmium					
Cd 109	330d	K	0.088		48A,48B
Cd 115	2.3d	0.46(60%)	0.52		48A,48B
		1.1	0.34		
		To In 115	(4.5h In 115)		
Cd 115	43d	1.67	0.5	48B-P	48A,48B
Calcium					
Ca 45	180d	0.254	None	20-PA,20-PB 20-PC,20-PE	20,21
Carbon					
C 14	5740y	0.154	None	6A-P,6B-P	56
Cerium					
Ce 141	28d	0.41(70%)	0.141	58-FA	58
		0.56(30%)	0.315		
Ce 143	33h	1.36	0.5		58
Ce 144	275d	0.3	None	58-FA,58-FB	
Cesium					
Cs 131	10.2d	K	None		58
Cs 134	2.3y	0.090(25%)	0.568(25%)	55-P	55
		0.658(75%)	0.602(100%)		
			0.794(100%)		
			~1.35		
Cs 137	37y	1.2(5%)	None	55-F	
		0.52(95%)	0.662		
		To Ba 137	(2.6m Ba 137)		

1184948

Element and isotope	Half-life	Radiation, Mev		Catalog item No.	
		Beta	Gamma	Table 1 processed	Table 2 unprocessed
Chlorine					
Cl 36	4.4×10^5y	0.71	?	17-P	17
Chromium					
Cr 51	26d	K	0.267		24
			0.32		
Cobalt					
Co 60	5.2y	0.31	1.17	27-P	27
			1.33		
Copper					
Cu 64	12.8h	0.57 β^-			29
		0.65 β^+			
		K	1.34		
Europium					
Eu 152	5.3y	0.9(80%)	~0.3		63,63A
		1.7(20%)			
		K	~1.2		
Eu 154	5.4y	0.3(50%)	~1.2		63,63A
		0.7(40%)			
		1.9(10%)			
Note: Radiation from Eu 152 or Eu 154 produced by Eu(n,γ) is not distinguishable from that of the other isotope.					
Eu 152, 154		K	11 γ's		
		0.75	$0.040 < E_\gamma < 1.402$		
		1.57			
Gallium					
Ga 72	14.25h	0.56	0.631		31
		0.74	0.69		
		1.00	0.83		
		1.45	1.05		
		1.75	1.47		
		2.57	1.57		
		3.17	1.81		
			2.18		
			2.50		
Germanium					
Ge 71	11.4d	K	None		33B,33C
Ge 77	12h	1.74	0.5		33B,33C
Gold					
Au 197	7.4s	I.T.	0.273		80A,80B
Au 198	2.69d	0.97	0.411		79A
Au 199	3.3d	0.32	0.024(?)		79B
			0.051		
			0.070(?)		
			0.156		
			0.207		
			0.23(?)		

1184949

Element and isotope	Half-life	Radiation, Mev		Catalog item No.	
		Beta	Gamma	Table 1 processed	Table 2 unprocessed
Hafnium					
Hf 181	46d	0.405	0.087 0.133 0.136 0.344(?) 0.480		72A
Hydrogen					
H 3 (Tritium)	12.5y	0.0189	None	1A-P,1B-P	
Indium					
In 114	50d	I.T.	0.192		49A,49B
	72s	2.05 β^-(97%)	0.548		
		K(3%)	0.715		
		0.650 β^+(0.01%)	1.27		
Iodine					
I 131	8.0d	0.32(15%) 0.60(85%)	0.638 0.364 0.284 0.080 ~0.16 (12.0d Xe 131)	53-F	53
Iridium					
Ir 192	70d	0.67	12 γ's $0.137 < E_\gamma < 0.651$	77A-P	77A,77B
Ir 194	19h	2.18 0.48	0.38 1.43		77A,77B
Iron					
Fe 55	2.91y	K	None	26-PA,26-PB 26-PE	26
Fe 59	46.3d	0.26(50%) 0.46(50%)	1.3 1.1	26-PB 26-PE	26
Lanthanum					
La 140	40.4h	1.32(70%) 1.67(20%) 2.26(10%)	0.093 0.335 0.49 0.82 1.6 2.55(4%) 2.9(6.1%)		57

1184950

Element and isotope	Half-life	Radiation, Mev		Catalog item No.	
		Beta	Gamma	Table 1 processed	Table 2 unprocessed
Mercury					
Hg 197	65h	K	0.077		80A,80B
	25h	K	0.135		
			0.165		
			0.273		
			(7.4s Au 197)		
Hg 203	43.5d	0.205	0.286	80B-P	80A,80B
Molybdenum					
Mo 99	68.3h	~0.5	0.181(?)		42,43
		1.22	0.360(?)		
			0.141		
			(5.9h Tc 99?)		
			Probably 3 γ's		
			$0.74 < E_\gamma < 0.84$		
Neodymium					
Nd 147	11d	0.17(33%)	0.035	60-F	61
		0.78(67%)	(γ or X ray)		
			0.58		
Nickel					
Ni 59	$\sim 2 \times 10^5$y	K			28
Ni 63	85y	0.06	None	28-P	28
Niobium					
Nb 95	90h	I.T.	0.216	40-F,41-F	40
	35d	0.146	0.758		
Osmium					
Os 185	97d	K	0.648(85%)		76
			0.878(15%)		
Os 191	15d	0.142	0.039		76
			0.127		
Os 193	32h	1.10	0.14 e^-(?)		76
			1.58(?)		
Palladium					
Pd 103	17d	K	None		46,47B
Pd 109	13.1h	0.95	None		46
Phosphorus					
P 32	14.3d	1.712	None	15A-P,15B-P	15,16,17
Platinum					
Pt 197	18d	0.65	None		79B
	82d(?)	~0.54	0.6		
Polonium					
Po 210	140d	5.298 α	0.8(weak)		83

1184951

Element and isotope	Half-life	Radiation, Mev		Catalog item No.	
		Beta	Gamma	Table 1 processed	Table 2 unprocessed
Potassium					
K 42	12.44h	3.58(75%)			15,17,19,35
		2.04(25%)	1.51		
Praseodymium					
Pr 142	18.9h	0.66	0.134		59
		2.23	0.329		
			0.490		
			0.624		
			1.59		
Pr 143	13.8d	0.92	None	59-F	58
Pr 144	17.5m	3.07	0.135(weak)	58-FA	
			1.25(weak)	58-FB	
Promethium					
Pm 147	2-4y	0.223	None	61-F	61
Pm 149	47h	1.1	0.25(weak)		61
Rhenium					
Re 186	92.8h	0.64(3%)	0.132(37%)		75
		0.95(30%)	0.275(23%)		
		1.09(67%)	1.7(0.7%)		
Re 188	18.9h	2.10	0.15		75
			0.48		
			0.64		
			0.95		
			1.40		
Rhodium					
Rh 105	36.5h	0.78	0.33		44A,44B
Rh 106	30s	3.55(82%)		44-FA,44-FB	
		2.30(18%)	0.51, 0.73 (17%)		
			1.25(1%)		
			>2.23		
Rubidium					
Rb 86	19.5d	1.822(80%)			37A,37B
		0.716(20%)	1.081		
Ruthenium					
Ru 97	2.8d	K	0.22		44A,44B
Ru 103	42d	0.222(~50%)	0.494	44-FA	44A,44B
		0.684(~50%)			
Ru 106	1.0y	0.041	None	44-FA,44-FB	
Samarium					
Sm 153	47h	0.68(67%)	0.0695		62
		0.80(33%)	0.103		
			0.61(weak)		

1184952

Element and isotope	Half-life	Radiation, Mev		Catalog item No.	
		Beta	Gamma	Table 1 processed	Table 2 unprocessed
Scandium					
Sc 46	85d	0.36(98%)	0.89	21-P	21
		1.49(2%)	1.12		
Selenium					
Se 75	127d	K	10 γ's	34-P	34
			$0.067 < E_\gamma < 0.405$		
Silver					
Ag 110	270d	0.087(58%)	0.676(weak)	47A-P	47A
		0.53(35%)	0.706(weak)		
			0.759(weak)		
			0.814(weak)		
			0.885(81%)		
			0.935(31%)		
			1.389(33%)		
			1.516(17%)		
		I.T.	0.116		
	24.5s	Soft			
		~2.12	0.656(100%)		
		2.86			
Ag 111	7.5d	1.06	None		46,47B
Sodium					
Na 24	14.9h	1.39	2.758		11
			1.380		
Strontium					
Sr 89	53d	1.50	None	38-FA	38
Sr 90	25y	0.537	None	38-FA,38-FB	
Sulfur					
S 35	87.1d	0.167	None	16-PA,16-PB 16-PC	16,17
Tantalum					
Ta 182	117d	0.25(?)	33 γ's	73-P	73
		0.53	$0.0462 < E_\gamma < 1.237$		
Technetium					
Tc 97	90d	I.T.	0.097		44A,44B
	$>10^3$y				
Tc 99	~3×10^5y	0.3	None	43-F	43
Tellurium					
Te 127	90d	I.T.	0.089		53
	9.3h	~0.8	None		
Te 129	32d	I.T.	0.106		53
	72m	1.8	0.3		
			0.8		
Te 131	1.25d	I.T.	0.177		53
	[illegible]	[illegible]	None		

1184953

Element and isotope	Half-life	Radiation, Mev Beta	Gamma	Catalog item No. Table 1 processed	Table 2 unprocessed
Thallium					
Tl 204	2.7y	0.783	None	81-P	81
Tin					
Sn 113	112d	K	~0.09	50-P	51C
Sn 121	1.1d	0.35	None		51C
	Long	0.41			
Sn 123	130d	1.3	None		51C
Tungsten					
W 185	73.2d	0.43	0.134(?)	74A-P	74A,74B
W 187	24.1h	1.318			74A,74B
		0.627	0.078		
			0.133		
			0.478		
			0.615		
			0.680		
Xenon					
Xe 131	12.0d	I.T.	~0.165		53
Yttrium					
Y 90	61h	2.18	None	38-FA 38-FB	39
Y 91	57d	1.537	0.2 | very	39-F	
			1.22 | weak		
Zinc					
Zn 65	250d	K(46%)	1.11	30-P	30
		K(51%)	None		
		0.32β^+ (~3%)			
Zn 69	13.8h	I.T.	0.439		30
	52m	0.86	None		
Zirconium					
Zr 95	65d	0.4	0.708	40-F	40
		0.887(2%)			
		To 90h Nb 95			
			0.216		
			(90h Nb 95)		
Zr 97	17h	2.2	~0.8		40

DEFINITIONS AND SHIPPING INFORMATION

Tables 1 and 2 furnish information concerning the forms in which the reactor-produced isotopes are available for distribution. Table 1 lists the isotopes which have been chemically processed after removal from the nuclear reactor; included are fission products, isotopes produced by (n,α), (n,p), and (n,γ) reactions. Table 2 lists irradiated units which are shipped without processing after removal from the reactor.

1184954

The definitions and other information shown below apply to the items appearing in Tables 1 and 2.

Millicurie — A millicure is 3.7×10^7 disintegrations per second. (For cases in which there is an indeterminate mixture of isotopes, absolute measurements cannot be given, and the "millicurie" means 3.7×10^7 beta-ray emissions per second in the sample.)

Irradiated Unit — An irradiated unit is a specified quantity of target material that has been sealed in an aluminum container and irradiated in the nuclear reactor. Irradiated units are offered with the understanding that, owing to variations in production factors, total activities may differ as much as 50 per cent from the estimated values.

Flux — In general activities are calculated for a flux of 5×10^{11} neutrons/cm^2/sec.

Fission Products — Fission products are radioisotopes separated from uranium, neptunium, and plutonium. They are separated from the fission mixture either as individual species or groups of species.

Target Materials — The target materials used for the production of radioisotopes are, in general the purest commercial substances that can be obtained. They are chosen so as to produce (other than the desired radioisotope) (1) no radioisotopes, (2) short-lived radioisotopes, or (3) radioisotopes easily separated from those produced by the target element. Oxides of metallic elements make suitable target compounds, since oxygen is not activated. Other compounds such as halides, nitrates, or carbonates are usually satisfactory, provided they are normally stable at pile operating temperature of 150°C. From time to time the compounds shown as target materials in Table 2 may be changed either because a purer substance is available, or because of a change in production techniques.

Shipment — Radiomaterial contained in a single shipping container constitutes a shipment. Shipments are made f.o.b. the reactor site. All transportation costs, including return of nonexpendable shipping containers, will be paid by the applicant.

Handling Charge — A charge of $10.00 will be made to cover handling costs for each shipment.

Container Deposit — A deposit of $125.00 will be required on returnable containers used to ship gamma-ray emitters. (Containers for pure beta-ray emitters need not be returned.) A refund will be made upon return of the container in good condition, express prepaid, within 21 days from the date of shipment. (For containers used to ship materials to foreign countries, a refund will be made if containers are returned within 30 days from receipt of shipment.) Such containers must not be used for any product other than that shipped therein. Charges will be made for damaged or missing parts.

Shipping Days — The following schedule applies to shipments of radioisotopes from Oak Ridge National Laboratory. All shipments will be made in accordance with this schedule; variations will be made only in cases of extreme urgency.

Phosphorus 32 — Monday,* Thursday, Friday
Iodine 131 — Tuesday,* Thursday, Friday
Unprocessed units (half-life <7 days) — Monday
Unprocessed units (half-life >7 days) — Wednesday
Carbon 14 and labeled compounds — Friday
Sulfur 35 — Thursday
Fission products — Thursday
Cobalt 60 (metallic) — shipped as packed
All other radioisotopes — Thursday

Purchase Orders — All purchase orders should be made out to Oak Ridge National Laboratory and should refer to the authorization number; customarily shipment will not be made unless this reference appears on the purchase order. Purchase orders for processed radioisotopes should be received by Oak Ridge National Laboratory 7 days prior to the requested shipping

*Principal shipping days for P 32 and I 131.

1184955

date; the Laboratory may in special cases accept emergency purchase orders received not less than 48 hr in advance of shipment. In the case of unprocessed units, the purchase order must be received 7 to 10 days before the target material is to be placed in the pile.

(Note: Some radioisotopes may be available both as processed material and as unprocessed irradiated units. Be sure to check the index for all available forms and request the material in a form best suited to the needs of the particular research problem.)

Table 1 — Processed Radioisotopes
(Listed in Order of Atomic Number)

Catalog item No.	Isotope and mode of production	Chemical and radioactive specifications	Price
1A-P	Hydrogen 3 (tritium) $Li^6(n,\alpha)H^3$	Chemical form, gas containing varying amounts of He 3 daughter Radiochemical purity, >99% (exclusive of daughter) Packaged in glass tubes with breakoff seal; amounts from 1 mc to 13.5 curies available	$0.10/mc 2.00 package charge for <100 mc
1B-P	Tritium-zirconium targets	2–3 cc of tritium per target ~2.6 curies of tritium per cubic centimeter Targets prepared on tungsten disks 2 cm diam., 0.025 in. thick Zirconium thickness ~0.002 in.	100.00/curie of tritium 100.00 labor charge
6A-P	Carbon 14 $N^{14}(n,p)C^{14}$	Chemical form, solid $BaCO_3$ Concentration, up to 12% of carbon atoms radioactive	36.00/mc
6B-P	Carbon 14 $N^{14}(n,p)C^{14}$	Chemical form, solid $BaCO_3$ Concentration, >12% of carbon atoms radioactive (Ordinarily this material will range from 16 to 20%; occasionally C 14 of higher concentration will be on hand)	36.00/mc
6C-P	Carbon 14 polystyrene sheets	See page 31	

1184956

Table 1 (Continued)

Catalog item No.	Isotope and mode of production	Chemical and radioactive specifications	Price
15A-P	Phosphorus 32 $S^{32}(n,p)P^{32}$	Chemical form, H_3PO_4 Specific activity, ~0.025 mg of stable P added per millicurie; (carrier-free material available, but there will be delay in procurement) Radiochemical purity, >99% Concentration, >0.5 mc/ml Acidity, <0.5N HCl Total solids, <10 mg/ml Nonvolatile matter, <5 mg/ml Fe, Ni, and Al, content such that no precipitate present at pH 7 to 9 after 24 hr	$1.10/mc
15B-P	Phosphorus 32 Bakelite plaques	Plaques made from 50-50 mixture of red phosphorus and bakelite Available sizes, 1 in. diam. × 0.19 in. thick (~4 g) 3 in. diam. × 0.19 in. thick (~30 g) Radiation intensity (surface), 1-in. plaque, up to 2000 rep; 3-in. plaque, up to 15,000 rep Shipped after one week of radioactive decay (Reference to method for measurement of surface intensity, ORNL-264)	40.00/plaque
16-PA	Sulfur 35 $Cl^{35}(n,p)S^{35}$	Chemical form, H_2SO_4 in 0.1N HCl Specific activity, carrier free Radiochemical purity, >99% Concentration, >1 mc/ml Total solids, <10 mg/ml Nonvolatile matter, <5 mg/ml Total sulfur as sulfate, <0.05 mg of SO_4 per millicurie of S 35 P 32, <0.01%	2.00/mc (1–10 mc) 1.00/mc (>10 mc)

1184957

Table 1 (Continued)

Catalog item No.	Isotope and mode of production	Chemical and radioactive specifications	Price
16-PB	Sulfur 35 $Cl^{35}(n,p)S^{35}$	Chemical form, BaS in $Ba(OH)_2$ solution (Shipped under nitrogen in sealed ampules) Specific activity, >10,000 mc/g of S (Includes decay in storage; solutions up to three times this specific activity available immediately after preparation) Radiochemical purity, >99% Concentration, >5 mc/ml $Ba(OH)_2$ added, <2.5 mg/mc of S 35 Sulfur as sulfide, ~70% Nonsulfide sulfur, ~30% P 32, none	$4.00/mc (1–10 mc) 1.50/mc (>10 mc)
16-PC	Sulfur 35 $Cl^{35}(n,p)S^{35}$	Chemical form, elemental sulfur Specific activity, 1 mc/mg Radiochemical purity, >99%	5.00/mc (1–10 mc) 2.00/mc (>10 mc)
17-P	Chlorine 36 $Cl^{35}(n,\gamma)Cl^{36}$	Chemical form, HCl Specific activity, 0.01–0.2 mc/g Radiochemical purity, >99% Concentration, >0.2 mc/ml HCl concentration, 1N–2N	5.00/μc
18-F	Argon 37 $Ca^{40}(n,\alpha)A^{37}$	Chemical form, argon diluted with CO_2 (gas) Packaged in tubes with breakoff seal, below atmospheric pressure	10.00/mc
20-PA	Calcium 45 $Sc^{45}(n,p)Ca^{45}$	Chemical form, chloride in acid solution Specific activity, carrier free Radiochemical purity, >99% Concentration, >0.1 μc/ml Total solids, <1 mg/ml Acidity, <1N HCl	4.00/μc
20-PB	Calcium 45 $Ca^{44}(n,\gamma)Ca^{45}$	Chemical form, chloride in acid solution Specific activity, 0.2–0.4 mc/g Radiochemical purity, >99% Concentration, >0.01 mc/ml Acidity, <0.5N HCl Heavy metals, <10 ppm	2.00/mc

1184958

Table 1 (Continued)

Catalog item No.	Isotope and mode of production	Chemical and radioactive specifications	Price
20-PC	Calcium 45 $Ca^{44}(n,\gamma)Ca^{45}$	Chemical form, chloride in acid solution Specific activity, 5–20 mc/g Radiochemical purity, >99% Concentration, >1 mc/ml Acidity, <1N HCl Heavy metals, <10 ppm	$5.00/mc
20-PX	Calcium 45 Ca^{44}(enriched) $(n,\gamma)Ca^{45}$	Chemical form, chloride in acid solution Specific activity, 1000 mc/g Radiochemical purity, >99% Concentration, >1 mc/ml Acidity, <1N HCl Heavy metals, <10 ppm	45.00/mc
21-P	Scandium 46 $Sc^{45}(n,\gamma)Sc^{46}$	Chemical form, chloride in acid solution Specific activity, >5000 mc/g Radiochemical purity, >99% Concentration, >1 mc/ml Acidity, <1N HCl	3.00/mc
24-P	Chromium 51 $Cr^{50}(n,\gamma)Cr^{51}$	Chemical form, chloride in acid solution Specific activity, ~10 mc/g Concentration, >0.05 mc/ml Acidity, <1N HCl	1.00/mc
26-PA	Iron 55 Fe^{54}(enriched) $(n,\gamma)Fe^{55}$	Chemical form, chloride in acid solution Specific activity, 300 mc/g Radiochemical purity, >99% (exclusive of Fe 59) Concentration, >0.5 mc/ml Acidity, <1N HCl Fe 59, <10%	50.00/mc
26-PB	Iron 59 Iron 55 $Fe^{58}(n,\gamma)Fe^{59}$ $Fe^{54}(n,\gamma)Fe^{55}$	Chemical form, chloride in acid solution Specific acitivity, >1 mc/g of Fe Radiochemical purity, >99% (exclusive of Fe 55) Concentration, >0.1 mc/ml Acidity, <1N HCl	35.00/mc
26-PX	Iron 59 Iron 55 Fe^{58}(enriched) $(n,\gamma)Fe^{59}$	Chemical form, chloride in acid solution Specific activity, >500 mc/g of Fe Radiochemical purity, >99% (exclusive of Fe 55) Concentration, >0.5 mc/ml Acidity, <1N HCl	50.00/mc

1184959

Table 1 (Continued)

Catalog item No.	Isotope and mode of production	Chemical and radioactive specifications	Price
27-P	Cobalt 60 $Co^{59}(n,\gamma)Co^{60}$	Chemical form, chloride in acid solution Specific activity, >100 mc/g of Co Radiochemical purity, >99% Concentration, >1 mc/ml Acidity, < 1N HCl	$2.00/mc
	Cobalt 60	See pages 28-30 for information concerning additional forms of high-specific-activity Co 60	
28-P	Nickel 63 Nickel 59 $Ni^{62}(n,\gamma)Ni^{63}$	Chemical form, chloride in acid solution Specific activity, 5 – 50 mc/g Radiochemical purity, > 95% Concentration, >1 mc/ml Acidity, < 1N HCl Ratio of Ni 63 to Ni 59 ~ 1000 to 1	45.00/mc
30-P	Zinc 65 $Zn^{64}(n,\gamma)Zn^{65}$	Chemical form, chloride in acid solution Specific activity, 75 – 300 mc/g Radiochemical purity, >98% Concentration, >1 mc/ml Acidity, <1N HCl	2.00/mc
34-P	Selenium 75 $Se^{74}(n,\gamma)Se^{75}$	Chemical form, chloride in acid solution Specific activity, 50 – 100 mc/g Radiochemical purity, >95% Concentration, >1 mc/ml Acidity, <1N HCl	1.00/mc
38-FA	Strontium 89 Strontium 90 Yttrium 90* Fission product	Chemical form, chloride in acid solution Radiochemical purity (excluding daughter activities), >95% Concentration, >1 mc/ml Total nonvolatile solids, <5 mg/ml Acidity, <3N HCl Heavy metals, <10 ppm Sr 90, <10%	1.00/mc (1 – 100 mc) 0.50/mc (>100 mc)
38-FB	Strontium 90 Yttrium 90* Fission product (aged material)	Chemical form, chloride in acid solution Radiochemical purity (excluding daughter activities), >95% Concentration, >1 mc/ml Total nonvolatile solids, <5 mg/ml Acidity, <3N HCl Heavy metals, <10 ppm Sr 89, <10%	1.00/mc (1 – 100 mc) 0.50/mc (>100 mc)

*Radioactive daughter.

1184960

Table 1 (Continued)

Catalog item No.	Isotope and mode of production	Chemical and radioactive specifications	Price
39-F	Yttrium 91 Fission product	Chemical form, chloride in acid solution Radiochemical purity, >95% Concentration, >1 mc/ml Total nonvolatile solids, <5 mg/ml Acidity, <3N HCl Heavy metals, <10 ppm	$1.00/mc (1-100 mc) 0.50/mc (>100 mc)
40-F	Zirconium 95 Niobium 95* Fission product	Chemical form, oxalate complex in oxalic acid solution Radiochemical purity (excluding daughter activities), >95% Concentration, >1 mc/ml Acidity, <1N	1.00/mc (1-100 mc) 0.50/mc (>100 mc)
41-F	Niobium 95 Fission product	Chemical form, oxalate complex in oxalic acid solution; also furnished complexed in citric acid Radiochemical purity (excluding daughter activities), >95% Concentration, >1 mc/ml Acidity, >1N	10.00/mc (1-50 mc) 5.00/mc (>50 mc)
43-F	Technetium 99 Fission product	Chemical form, NH_4TcO_4 in weak NH_4OH Specific activity, carrier free Radiochemical purity, >99.5% Concentration, 0.5-1 mg/ml	250.00/mg (1-10 mg) 100.00/mg (>10 mg)
44-FA	Ruthenium 103 Ruthenium 106 Rhodium 106* Fission product	Chemical form, chloride in acid solution Specific activity, 5000 mc/g of Ru Radiochemical purity (excluding daughter activities), >95% Concentration, >1 mc/ml Acidity, ~6N HCl Total nonvolatile solids, <10 mg/ml Ru 106, <10%	5.00/mc (1-50 mc) 2.00/mc (>50 mc)
44-FB	Ruthenium 106 Rhodium 106* Fission product	Chemical form, chloride in acid solution Specific activity, >2000 mc of Ru 106 per gram of Ru Radiochemical purity, >95% Acidity, ~6N HCl Total nonvolatile solids, <10 mg/ml Ru 103, <10%	10.00/mc (1-50 mc) 5.00/mc (>50 mc)

*Radioactive daughter.

1184961

Table 1 (Continued)

Catalog item No.	Isotope and mode of production	Chemical and radioactive specifications	Price
47A-P	Silver 110 $Ag^{109}(n,\gamma)Ag^{110}$	Chemical form, nitrate in acid solution Specific activity, 100 – 300 mc/g Radiochemical purity, >95% Concentration, >1 mc/ml Acidity, <1N HNO_3	$1.00/mc
48B-P	Cadmium 115 $Cd^{114}(n,\gamma)Cd^{115}$	Chemical form, nitrate in acid solution Specific activity, 5 – 20 mc/g Radiochemical purity, >95% (exclusive of Cd 109) Concentration, >0.01 mc/ml Acidity, <1N HNO_3	33.00/mc
50-P	Tin 113 $Sn^{112}(n,\gamma)Sn^{113}$	Chemical form, chloride in acid solution Specific activity, 10 – 50 mc/g Radiochemical purity, >95% Concentration, >0.5 mc/ml Acidity, ~6N HCl	35.00/mc
51B-P	Antimony 124 $Sb^{123}(n,\gamma)Sb^{124}$	Chemical form, chloride in acid solution Specific activity, 200 – 500 mc/g Radiochemical purity, >95% Concentration, >0.5 mc/ml Acidity, <6N HCl	3.00/mc
51C-P	Antimony 125 $Sn^{124}(n,\gamma)$ $Sn^{125} \xrightarrow{\beta^-} Sb^{125}$	Chemical form, chloride in acid solution Specific activity, carrier free Radiochemical purity, >99% (exclusive of metastable Te 125) Concentration, >0.05 mc/ml Acidity, <6N HCl	100.00/mc
51D-P	Antimony-beryllium neutron sources	See page 30	
53-F	Iodine 131 Fission product	Chemical form, iodide in weak basic sodium sulfite solution Specific activity, carrier free Radiochemical purity, >99% Concentration, >1 mc/ml Total solids (principally NaOH and Na_2SO_3), <5 mg/ml Heavy metals, >10 ppm pH, 7 to 9	0.75/mc

1184962

Tab'e 1 (Continued)

Catalog item No.	Isotope and mode of production	Chemical and radioactive specifications	Price
55-P	Cesium 134 $Cs^{133}(n,\gamma)Cs^{134}$	Chemical form, chloride in acid solution Specific activity, 1000–2000 mc/g Radiochemical purity, >95% Concentration, >1 mc/ml Acidity, <1N HCl	$1.00/mc
55-F	Cesium 137 Barium 137* Fission product	Chemical form, chloride in acid solution Radiochemical purity (excluding daughter activities), >95% Concentration, >1 mc/ml Total nonvolatile solids, <10 mg/ml Acidity, <1N HCl	2.00/mc (1–50 mc) 1.00/mc (>50 mc)
56-F	Barium 140 Lanthanum 140* Fission product	Chemical form, chloride in acid solution Radiochemical purity (excluding daughter activities), >95% Concentration, >1 mc/ml Total nonvolatile solids, <10 mg/ml Acidity, <1N HCl	1.00/mc (1–100 mc) 0.50/mc (>100 mc)
58-FA	Cerium 141 Cerium 144 Praseodymium 144* Fission product	Chemical form, chloride in acid solution Radiochemical purity (excluding daughter activities), >95% Concentration, >1 mc/ml Total nonvolatile solids, <10 mg/ml Acidity, <1N HCl	1.00/mc (1–100 mc) 0.50/mc (>100 mc)
58-FB	Cerium 144 Praseodymium 144* Fission product (aged material)	Chemical form, chloride in acid solution Radiochemical purity (excluding daughter activities), >95% Concentration, >1 mc/ml Total nonvolatile solids, <10 mg/ml Acidity, <1N HCl	1.00/mc (1–100 mc) 0.50/mc (>100 mc)
59-F	Praseodymium 143 Fission product	Chemical form, chloride in acid solution Radiochemical purity, >95% Concentration, >1 mc/ml Total nonvolatile solids, <10 mg/ml Acidity, <1N HCl	50.00/mc (1–10 mc) 12.00/mc (>10 mc)
60-F	Neodymium 147 Fission product	Chemical form, chloride in acid solution Radiochemical purity (excluding daughter activities), >95% Concentration, >1 mc/ml Total nonvolatile solids, <10 mg/ml Acidity, <1N HCl	50.00/mc (1–10 mc) 12.00/mc (>10 mc)

*Radioactive daughter.

1184963

Table 1 (Continued)

Catalog item No.	Isotope and mode of production	Chemical and radioactive specifications	Price
61-F	Promethium 147 Fission product	Chemical form, chloride in acid solution Radiochemical purity (excluding daughter activities), >95% Concentration, >1 mc/ml Total nonvolatile solids, <10 mg/ml Acidity, <1N HCl	$75.00/mc (1-10 mc) 20.00/mc (>10 mc)
73-P	Tantalum 182 $Ta^{181}(n,\gamma)Ta^{182}$	Chemical form, tantalate in KOH solution Specific activity, 1000-3000 mc/g Concentration, >0.5 mc/ml Basicity, <1N KOH	2.00/mc
74A-P	Tungsten 185 $W^{184}(n,\gamma)W^{185}$	Chemical form, tungstate in KOH solution Specific activity, 100-300 mc/g Concentration, >0.5 mc/ml Basicity, <1N KOH	4.00/mc
77A-P	Iridium 192 $Ir^{191}(n,\gamma)Ir^{192}$	Chemical form, chloride in acid solution Specific activity, 1000-5000 mc/g Concentration, >1 mc/ml Acidity, <6N HCl	1.00/mc
80B-P	Mercury 203 $Hg^{202}(n,\gamma)Hg^{203}$	Chemical form, nitrate in acid solution Specific activity, 25-50 mc/g Concentration, >1 mc/ml Acidity, <6N HNO_3	1.00/mc
81-P	Thallium 204 $Tl^{203}(n,\gamma)Tl^{204}$	Chemical form, nitrate in acid solution Specific activity, 25-100 mc/g Concentration, >1 mc/ml Acidity, <1N HNO_3	5.00/mc

1184964

.00
.00
.00
1.00
2.00
3.00
3.00
4.00
3.00
13.00
13.00
12.00
13.00
13.00
12.00
46.00
32.00

Table 2 (Continued)

Catalog item No.	Isotope	Others present	Target material: Compound	Target material: Weight, g	Activity: Estimated quantity, mc	Activity: Specific activity, mc/g	Time of irradiation, weeks	Price per unit
34	Selenium 75		Se	20	65	3.3	4	$ 33.00
35	Bromine 82		KBr	0.9	70	120	1	12.00
		K 42			4.5	15		
37A	Rubidium 86		Rb_2CO_3	6.5	100	20	4	42.00
37B	Rubidium 86		1/10 of unit 37A				4	32.00
38	Strontium 89		$Sr(NO_3)_2$	33	1.5	0.11	4	33.00
39	Yttrium 90		Y_2O_3	1.1	100	115	1	33.00
40	Zirconium 95 (Parent of Nb 95)		$Zr(OH)_4$	2.2	0.06	0.05	1	12.00
		Zr 97			2	1.6		
		Nb 95				C.F.		
42	Molybdenum 99 (Parent of Tc 99)		MoO_3	10	46	7	1	12.00
		Tc 99*			Very small	C.F.		
43	Technetium 99*		MoO_3	6	0.00001	C.F.	4	33.00
		Mo 99			45	11		
44A	Ruthenium 97		RuO_3	5	10	3	1	44.00
		Tc 97*			1	C.F.		
		Ru 103			10	3		
		Rh 105			10	C.F.		
44B	Ruthenium 97		1/10 of unit 44A				1	32.00
46	Palladium 103		Pd	1		(Undetermined)	4	36.00
		Pd 109				(Undetermined)		
		Ag 111			10	C.F.		
47A	Silver 110		$AgNO_3$	7.1	13	3	4	33.00
47B	Silver 111		Pd	1	5	C.F.	1	15.00
		Pd 103			?	?		
48A	Cadmium 115		Cd	1	20	20	1	12.00
		Cd 109			?	?		
		Cd 115		0.3	0.3			
48B	Cadmium 115		Cd	1	1	1	4	33.00
		Cd 109			?	?		
		Cd 115			25	25		
49A	Indium 114		In	0.15	10	70	4	51.00

* Radioactive daughter

1184966

L96h811

Table 2 (Continued)

Catalog item No.	Isotope	Others present	Target material: Compound	Target material: Weight, g	Activity: Estimated quantity, mc	Activity: Specific activity, mc/g	Time of irradiation, weeks	Price per unit
							4	$33.00
49B	Indium 114		1/10 of unit 49A					
51A	Antimony 122		Sb	0.20	50	250	1	12.00
		Sb 124			3	15		
51B	Antimony 124		Sb	0.20	11	55	4	33.00
		Sb 122			55	275		
51C	Antimony 125		Sn	6.2	0.4	C.F.	4	33.00
		Sn 113			1.0	0.16		
		Sn 121			?	?		
		Sn 123			?	?		
53	Iodine 131*		Te	50	250	C.F.	4	33.00
		Xe 131*			2.5	C.F.		
		Te 127			10	0.20		
		Te 129			8	0.16		
		Te 131 (Parent of I 131)			10	0.20		
55	Cesium 134		Cs_2CO_3	0.6	20	40	4	34.00
56	Barium 131 (Parent of Cs 131)		$Ba(NO_3)_2$	44	6	0.26	4	33.00
		Cs 131*			9	C.F.		
		C 14			Trace			
57	Lanthanum 140		La_2O_3	0.09	40	525	1	12.00
58	Cerium 141		CeO_2	0.83	50	75	4	33.00
		Ce 143 (Parent of Pr 143)			12	18		
		Pr 143*			3	C.F.		
59	Praseodymium 142		Pr_2O_3	0.085	40	550	1	13.00
61	Promethium 147		Nd_2O_3	0.01	0.001	C.F.	4	31.00†
		Pm 149			0.1	C.F.		
		Nd 147			0.03	3.5		
62	Samarium 153		Sm_2O_3	0.01	8	1000	1	9.00†
		Eu 155			0.0001	C.F.		

*Radioactive daughter

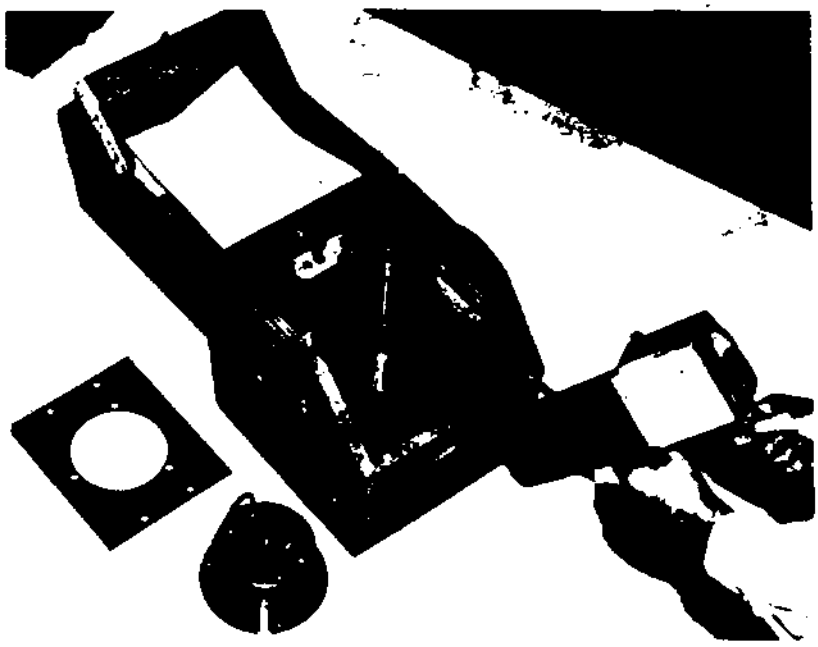
†Target material to be furnished by applicant.

Table 2 (Continued)

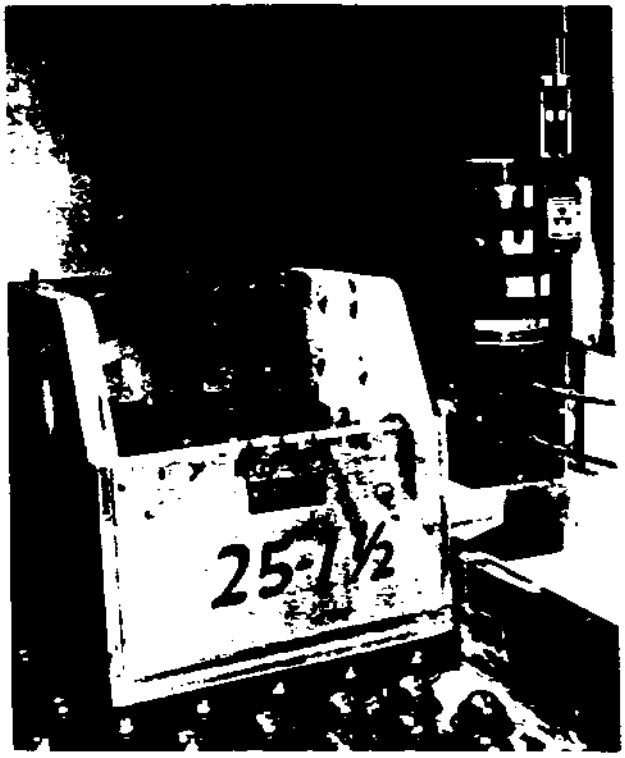
Catalog item No.	Isotope	Others present	Target material: Compound	Target material: Weight, g	Activity: Estimated quantity, mc	Activity: Specific activity, mc/g	Time of irradiation, weeks	Price per unit
63	Europium 152,154		$Eu_2(oxalate)_3$	0.40	52	240	4	$761.00
63A	Europium 152, 154		1/40 of unit 63				4	49.00
72A	Hafnium 181		HfO_2	0.9	50	60	4	64.00
72B	Hafnium 181		1/10 of unit 72A				4	34.00
73	Tantalum 182		Ta	0.19	20	105	4	33.00
74A	Tungsten 185		WO_3	1.8	10	7	4	33.00
		W 187			500	350		
74B	Tungsten 187		WO_3	0.12	35	350	1	12.00
		W 185			0.2	2.1		
75	Rhenium 186		Re	0.05	75	1500	1	12.00
		Re 188			120	2400		
76	Osmium 191		Os	0.55	40	73	4	35.00
		Os 185			?	?		
		Os 193			18	33		
77A	Iridium 192		Ir	0.19	40	210	4	35.00
		Ir 194			200	1050		
77B	Iridium 194		Ir	0.043	40	930	1	12.00
		Ir 192			3	70		
79A	Gold 198		Au	0.016	50	3000	1	12.00
79B	Gold 199		Pt	0.5	10	C.F.	1	12.00
		Pt 197			7	14		
80A	Mercury 197 (Parent of Au 197)		HgO	14	95	7	1	12.00
		Au 197*			7	?		
		Hg 203			12	0.9		
80B	Mercury 203		HgO	14	40	3	4	33.00
		Hg 197			110	9		
		Au 197			?	?		
81	Thallium 204		$TlNO_3$	6.8	7	1.3	4	33.00
83	Bismuth 210		Bi	24.5	10	0.4	1	14.00
		Po 210			0.3†	C.F.		

*Radioactive daughter.
†Maximum activity 25 days after removal from pile.

1184968

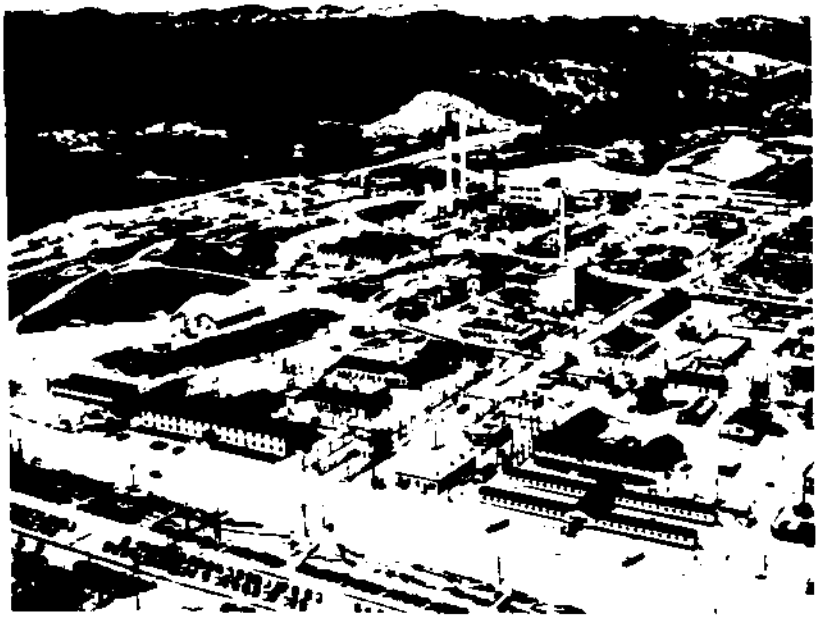


Radiation monitoring of shipping container for unprocessed units.

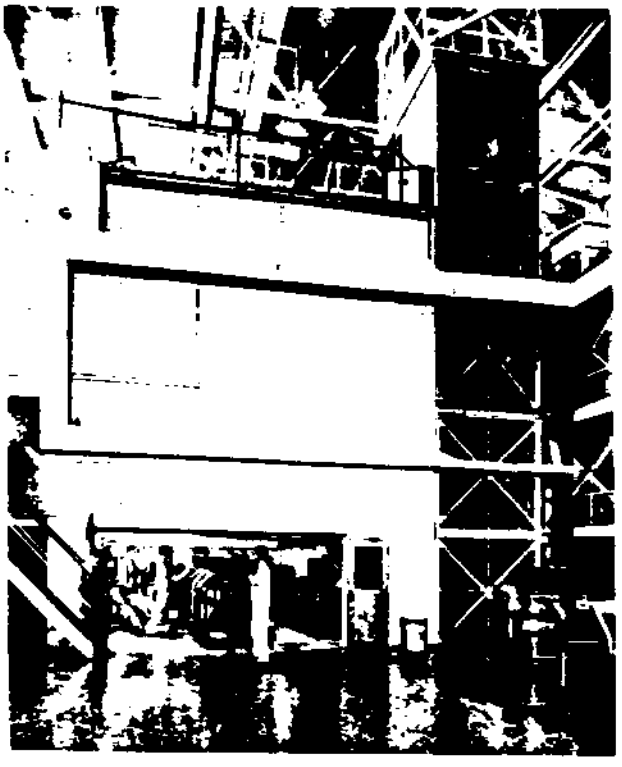


Shipping container for processed radioisotopes.

1184969

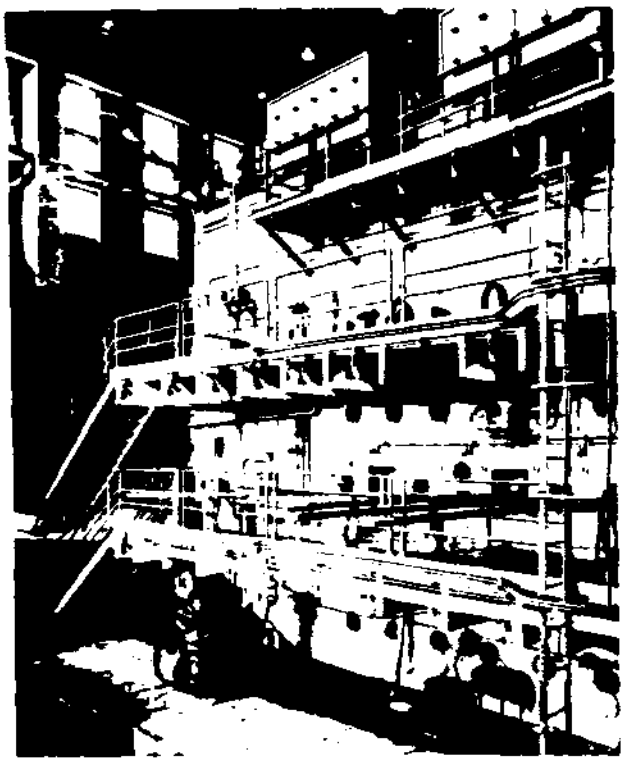


Oak Ridge National Laboratory, X-10 Area.



Nuclear reactor at Oak Ridge National Laboratory.

1184970



Experimental face of Brookhaven National Laboratory Nuclear reactor.

SPECIAL IRRADIATION SERVICES

Occasionally an applicant may wish to procure radioisotopes in forms not routinely available. In such cases, arrangements can be made for the irradiation of special target materials furnished by the applicant. Oak Ridge National Laboratory has offered this service for some time, and the Brookhaven National Laboratory will now offer this service also. Argonne National Laboratory can furnish reactor space, on a limited scale, for important research irradiations.

Oak Ridge National Laboratory

Materials to be irradiated are placed in a standard-sized aluminum cylinder having ¾ in. ID and 3 in. length. If the target cannot be placed directly in the aluminum cylinder, it should be sealed in quartz before it is sent to the Laboratory. Glass should not be used because of the radioactivities induced.

The quantity of material which may be placed in one unit is limited by the induced activities which may be safely shipped by a commercial carrier in a standard shipping container. The quantities of target materials shown in Table 2, Unprocessed Units, in this catalog give a general indication of the permissible range. All induced activities must be considered. The thermal neutron flux will be approximately 5×10^{11} neutrons/cm^2/sec.

Materials which may affect the safety of the reactor or are dangerous to handle will not be accepted. Acceptable materials must be nonvolatile at temperatures of 150°C.

Applicants must provide chemical and spectrographic analyses of targets to be irradiated and also sufficient quantities of these materials for check analyses if required.

1184971

Irradiation may produce changes in the molecular arrangement of compounds, thereby resulting in altered physical and chemical characteristics. This is particularly true in the case of organic compounds, in which degradation of the molecule is often effected.

The charges for irradiation services at Oak Ridge National Laboratory are as follows:

Irradiation for one week	$12.00
Irradiation for one month	33.00

There will be additional charges for any special services performed by the Laboratory, such as analytical work and special handling, or for target material if furnished by the Laboratory. These charges will vary for each irradiation, and preliminary correspondence should be forwarded to the Laboratory to learn details concerning the particular service. The handling charge of $10.00 per shipment and the shipping-container deposit, if necessary, remain the same as for other shipments.

Oak Ridge National Laboratory will, upon occasion, be able to irradiate samples with dimensions larger than those of the standard irradiation can. Such irradiations can be performed infrequently; therefore it is suggested that correspondence be directed to the Laboratory to learn details of feasibility and cost. Address correspondence to

Oak Ridge National Laboratory
Post Office Box P
Oak Ridge, Tenn.
Attention: Isotopes Control Department

Brookhaven National Laboratory

Brookhaven National Laboratory has facilities which make it well adapted for special irradiation services. The primary facility for these irradiations is an "endless chain" target conveyer traversing the center of a graphite-uranium nuclear reactor. This conveyer is capable of handling some 300 individual irradiations at one time, any one of which can be inserted into or removed from the reactor without the necessity of a shutdown; therefore samples may be charged or discharged daily. Special arrangements would have to be made for irradiations of less than 1 day in duration.

The maximum thermal neutron flux available at the center of the target conveyer will be approximately 4×10^{12} neutrons/cm^2/sec at routine operating level and will decrease to about 1.2×10^{11} neutrons/cm^2/sec at the extremities.

Materials should fit inside a standard Brookhaven National Laboratory service irradiation container made of 2S aluminum and having dimensions of ¾ in. ID and 2⅛ in. length. Samples exceeding these dimensions would require special arrangements with the Laboratory prior to submission of an application. Sample size will also be limited to that yielding a total activity which may be safely handled within 3 in. of lead for shipment under existing regulations.

Target compounds to be irradiated should be stable up to 200°C.

In general, prices for irradiations at Brookhaven National Laboratory will be based on the length of irradiation time and the neutron flux at which the sample is irradiated. Irradiation charge will be made according to the following formula:

$$\text{Cost in dollars} = \frac{\text{flux} \times \text{exposure time in days}}{4 \times 10^{11}}$$

Therefore an irradiation carried out in the center of the target conveyer at a flux of 4×10^{12} neutrons/cm^2/sec will cost $10.00 per day, whereas a similar irradiation at an edge position with a flux of 1.2×10^{11} neutrons/cm^2/sec will cost $0.30 per day. Total charges will be figured to the nearest dollar, and there will be a minimum charge of $1.00. These rates apply to the first 30 days of irradiation after which lower rates will become effective.

In addition to irradiation charges, there will be a handling charge of $25.00 for each container and charges for target material valued at more than $5.00. All shipments will be made via Railway Express, collect, f.o.b., Patchogue, Long Island, N. Y., unless otherwise requested. Shipments via

1184972

air will be made f.o.b., Upton, Long Island, N. Y., and will generally involve special motor transport to an airport. The customer is responsible for all shipping charges and return of shipping containers when necessary.

When returnable shipping containers are involved, a deposit will be required. This deposit will be refunded upon return of the container within three weeks of shipment. A demurrage charge per week will be deducted from the deposit after three weeks from date of shipment.

To assist in preliminary calculation of activities, the following formula may be used:

$$\text{Activity per gram of target element} = \frac{1.64\sigma F(1-e^{-0.693t/T_{1/2}})}{M} \text{ curies}$$

where σ = thermal neutron activation cross section in barns
F = thermal neutron flux $\times 10^{-11}$
M = molecular weight of element
t = time of irradiation
$T_{1/2}$ = half-life of isotopes (in same units as "t")

For isotopes whose half-life is very long compared to the time of irradiation, the following simplified formula may be used:

$$\text{Activity per gram of target element} = \frac{1.136\sigma Ft}{MT_{1/2}} \text{ curies}$$

Applicants in the northeastern part of the United States may obtain from Brookhaven National Laboratory nonprocessed radioisotopes as listed in Table 2. The price per unit will be the same, although the activities may be greater owing to the higher BNL flux. Handling charges will be $25.00 per shipment.

Correspondence concerning special irradiations and activities desired in unprocessed units should be addressed to

Brookhaven National Laboratory
Associated Universities, Inc.
Upton, Long Island, N. Y.
Attention: Isotopes and Special Materials Group

Argonne National Laboratory

The heavy-water reactor located at Argonne National Laboratory may occasionally be used for special irradiations that cannot be conveniently performed elsewhere. Ordinarily most reactor space is used for work at the Laboratory and for work being done by institutions participating in the Argonne program.

Such irradiations are made in central locations of the reactor or in pockets provided at its periphery. Samples are usually irradiated within an aluminum can with dimensions of ¾ in. ID by 5 in. length. A container with dimensions of 1⅛ in. ID by 5 in. length may also be accommodated. For details concerning temperature of irradiation, length of irradiation time, and specific activity to be obtained, inquiries should be directed to Argonne National Laboratory.

A basic charge of $25.00 will be made for all service irradiations. This fee will cover administration, handling, target material (if less than $2.00), activity of samples of less than 1 curie, and four weeks' demurrage on shipping container. In addition, the following charges will be made: (1) the cost of the target, if in excess of $2.00; (2) $15.00 per curie, computed to the nearest 0.33 curie, for all activities greater than 1 curie; (3) $25.00 per each additional container; and (4) demurrage charges of $1.50 per week on shipping containers, beginning the fifth week after shipment is made.

Shipments will be made f.o.b., Lemont, Ill., by Railway Express collect unless otherwise requested.

Correspondence should be addressed to

Argonne National Laboratory
Post Office Box 5207
Chicago 80, Ill.
Attention: Special Materials Department

1184973

Nuclear reactor at Argonne National Laboratory.

Activation Analysis

Through irradiation in a nuclear reactor, it is possible to activate minute quantities of impurities in a substance, and from the induced radioactivity, it is possible to make calculations as to the amount of the impurity. This method offers potentialities for being extremely sensitive and may allow quantitative determination of amounts of material far below the range of other chemical or physical testing methods.

Research is presently underway at Oak Ridge National Laboratory to determine the extent to which this service might be utilized. It is suggested that preliminary inquiries concerning a specific problem be forwarded to the Laboratory.

SPECIAL RADIOACTIVE MATERIALS

Metallic Cobalt 60 Sources

In many instances Co 60 may be effectively substituted for radium as a source of high-energy gamma rays. Cobalt 60 has a half-life of 5.3 years and emits beta rays having a maximum energy of 0.3 Mev and two monochromatic gamma rays of 1.1 and 1.3 Mev.

If the gamma-ray intensity of Co 60 is compared to that of radium, theoretically 1 mc of Co 60 will equal 1.55 mg of radium. The measured values may not agree exactly with theoretical values, since the measuring instruments in general use are energy dependent and may be more sensitive to low-energy gamma rays of the emission spectrum of radium and its decay products.

1184974

The Co 60 sources described below may be used wherever gamma rays are needed. However, routinely produced sources are particularly suitable to industrial radiography.

Separate paragraphs are devoted to descriptions of sources for medical use.

Routinely Produced Sources. Cobalt 60 with specific activities up to 4 curies/g of cobalt will be maintained in stock by Oak Ridge National Laboratory. The sources will be made from cobalt wire with diameters of 1 mm, ⅛ in., and 1 cm.

Various lengths of each diameter will be irradiated to different specific activities. The following table gives an indication of sizes and activities of sources which will be available:

Diameter	Length	Approximate range of activity, mc
1 mm	1 cm	10–250
⅛ in.	⅛ in.	150–800
¼ in.	¼ in.	300–1,600
1 cm	1 cm	1,000–28,000

Longer pieces of the same diameter will have correspondingly greater activities. Inquiries concerning specific source sizes and activities should be addressed to Oak Ridge National Laboratory, noting the characteristics of the source desired.

Encapsulation. The surface of cobalt metal, when bombarded with neutrons, is appreciably oxidized. When handled the cobalt oxide may flake off in small particles. These particles are highly radioactive; hence, there is a pronounced hazard of contaminating the working area. To reduce this danger to a minimum, Co 60 will be placed in tight capsules before shipment, unless specifically authorized otherwise.

The Oak Ridge National Laboratory fabricates capsules which accommodate sources ⅛ in. in diameter by ⅛ in. long or ¼ in. in diameter by ¼ in. long. These capsules are in two sections, one of brass or aluminum and the other of steel. The brass or aluminum end is equipped with an eye in order that the capsule may be handled with hooks or lines. The steel section is incorporated into the capsule so that electromagnetic handling tools may be used. The over-all dimensions of these capsules are 0.561 by 0.25 in. and 0.686 by 0.25 in. Arrangements may be made with the Laboratory to fabricate similar capsules capable of accommodating longer source sizes.

Cobalt 60 sources can be loaded into capsules furnished by the applicant. Before fabricating the capsule, the applicant should send a drawing to assure that the capsule will be adaptable to remote-handling equipment.

Service Irradiations. If the applicant desires the activity in a metallic source of a specific shape and size not available routinely, he should request a service irradiation of an appropriate target. The charges for this service are discussed on page 26. In most instances the applicant will be expected to furnish the target material. However, when the target can be cut from the material in stock, the Laboratory can furnish cobalt metal, but there will be a service charge for cutting and straightening. It is suggested that correspondence be directed to Oak Ridge National Laboratory concerning Co 60 in unusual sizes before a formal application is submitted to the Isotopes Division.

Needles or Small Sources for Medical Use. Cobalt 60 is also produced in a form suitable for interstitial use or for small radiation sources. Wire of pure cobalt may be irradiated and prepared as needles by being placed in sheaths. Samples of the wire (0.5 and 1 mm diameter) are on hand; however, the applicant may furnish his own wire if he so desires. All sheaths must be supplied by the applicant. Oak Ridge National Laboratory is prepared to place the irradiated wire in the sheaths and seal them with silver solder. A charge sufficient to cover the cost of the labor involved will be added to the price of the irradiation. A one-month period of irradiation is sufficient to produce an activity of about 4 mc/cm of pure cobalt wire 1 mm in diameter.

After the needles have been fabricated, arrangements can be made by the applicant for their calibration at the National Bureau of Standards or other suitable laboratory.

1184975

Several pieces of wire 0.5 and/or 1 mm in diameter with a total weight of about 3.5 g may be placed in a single can. (A greater weight may be placed in the can if absolute uniformity of activity is not essential.) This amount (3.5 g of cobalt) will be handled as one service irradiation to produce a gamma intensity corresponding to that from about 155 mg of radium with 0.5 mm of platinum filtration. As shown on page 26 of the catalog, the price of a one-month service irradiation would be $33.00, plus special fees and a $10.00 handling charge. The applicant will also pay shipping costs. The amount of Co 60 produced in 3.5 g of cobalt irradiated for one month would be shipped in a lead container with walls 3 in. thick; total weight would amount to about 240 lb.

Multicurie Sources for Medical Use. Cobalt 60 sources suitable for use in teletherapy units are not yet available. For this purpose a specific activity of 20 to 40 curies/g will be necessary to make sources of a practical size. Announcement will be made when Co 60 of suitable specific activity may be procured.

Prices for Radioactivity. The cost of Co 60 routinely produced at Oak Ridge National Laboratory is as follows:

Total activity per shipment, mc	Cost
1 – 20	$20.00
21 – 100	30.00
101 – 500	40.00
501 – 1000	50.00
1001 – 1500	75.00
1501 – 2000	100.00
>2000	100.00 plus $5.00/curie or a fraction thereof above 2 curies

An additional $10.00 will be charged for each piece of cobalt required in the shipment. The applicant will be expected to pay the regular $10.00 handling fee and shipping costs.

Prices for Encapsulation. A single standard-sized capsule will be furnished and loaded for $50.00. Each additional capsule in the same shipment will cost $25.00. Charges for larger capsules will be correspondingly greater. The cost for loading capsules furnished by the applicant will depend upon the amount of handling necessary; each such order will be considered individually.

Antimony-Beryllium Neutron Sources

Antimony slugs, coated with beryllium and sealed in aluminum jackets, may be irradiated to produce antimony-beryllium neutron sources. The neutron flux of the sources will be about 10^8 neutrons/sec, the exact value depending upon the length of activation time in the reactor. Sources are shipped in standard cylinder assemblies as follows:

Diameter of cylinder	13/16 in.
Lenght of cylinder	13/16 in.
Aluminum plate protruding perpendicularly from one end	3/8 in.
Hole in aluminum plate for handling	1/4 in.
Over-all length of assembly	~1 3/4 in.

The source itself and the irradiation time will be priced separately, so that a customer can choose one-, two-, three-, or four-month periods of irradiation. The shipping container, weighing approximately 350 lb, should be returned to Oak Ridge National Laboratory within three weeks after date of shipment.

1184976

The costs of the sources will be as follows:

Antimony-beryllium source	$ 44.00
Irradiation charge	33.00/month
Deposit on returnable container	400.00

The entire unit is placed in the pile, and the antimony is activated to the desired level. Antimony 122 (half-life 2.8 days) and Sb 124 (half-life 60 days and gamma-ray energies from 0.121 to approximately 2.3 Mev) are both formed in this irradiation, but most of the Sb 122 will decay in about two weeks. Saturation activity of the Sb 124 is approximately 3.5 curies; however, an activation time of 120 days will give an activity of about 2.6 curies. Shorter or longer activation periods may be arranged as required. After the activity of the Sb 124 has decayed, it may be reactivated by reinsertion in the reactor.

Because of the need for prompt return of containers, it will be necessary for a prospective user to plan, before receipt of a source, to construct a suitable storage unit. A lead pig with walls 4 to 5 in. thick, adequate for storage of the source, can be constructed at a relatively small cost.

Mixed Fission Products

Fission-product mixtures that have been separated from uranium and plutonium, but not from each other, can be used as strong sources of beta and gamma rays.

Oak Ridge National Laboratory can supply mixtures of short-lived radioisotopes separated from uranium that has been exposed in the nuclear reactor 40 to 60 days and cooled only a few days before separation. The mixed fission products are shipped as chlorides in weak HCl solution. The activities will be about 10 mc gross beta-ray counts (10 per cent geometry) per milliliter of solution and 10^8 to 10^9 gross gamma-ray counts (1 per cent efficiency and 10 per cent geometry) per minute per milliliter. Total solids will be less than 10 mg/ml. The price for this material will be $10.00 per millicurie for the first 3 mc and $0.75 per millicurie thereafter.

The above mixtures will be useful for research purposes where long-lived activities are not necessary. However, long-lived fission-product mixtures in multicurie amounts, produced from longer exposure of uranium in the reactor, are also available. Information as to specifications and price will be furnished upon request.

Should the demand warrant it, very large quantities of by-product fission mixtures could be made available. Since the separation and purification processes may differ, it is not possible to furnish general information as to specifications or chemical contaminants. For more detailed assistance, it is therefore suggested that specific problems be presented to the Isotopes Division.

Carbon 14 Labeled Polystyrene Sheets for Reference Sources

Sheets of polystyrene labeled with C 14 can be used to prepare reference sources of weak beta radiation for routine calibration of G-M tubes and other counting devices. The activity of the available material in terms of an average end-window G-M assembly (window thickness approximately 1.5 mg/cm^2, sample-to-counter distance approximately 10 mm, diameter of counter window 25 mm, and diameter of source 25 mm) is of the order of 3600 counts per minute. Lower specific-activity material may be prepared by dissolving the active polystyrene in an organic solvent and adding inert polystyrene.

Two pieces of polystyrene with the same dimensions, but prepared at different times, will not necessarily have the same activity, nor will two sides of the same piece necessarily give the same counting rate.

The thickness of these sheets is about 0.010 to 0.012 in.; this is somewhat greater than "infinite thickness," which is defined as that thickness of sample which will absorb all radiations from the lower layers of material and thus only top layers contribute to assay. The polystyrene is available in square sheets of two sizes: (1) 1¼ by 1¼ in., each weighing about 275 mg and containing 0.6 μc of C 14, price $5.00 per sheet, and (2) 5 by 5 in., each weighing about 4.4 g and containing 9.6 μc of C 14, price $80.00 per sheet.

1184977

There will be the usual handling charge of $10.00 for each shipment of polystyrene sheets.

Customers desiring one of the smaller sheets, 1¼ by 1¼ in., may obtain it from Oak Ridge National Laboratory without specific authorization. For more than one of the smaller sheets or any number of larger sheets, it is necessary first to submit an Application for Radioisotope Procurement, Form AEC-313, to the Isotopes Division.

(NOTE: When used with internal counters, the polystyrene sources sometimes give counting rates which decrease with time by as much as a factor of 5 during the first few minutes of operation. This phenomenon may be caused by the building up of a static charge on the surface of the sheet. A thin ring of aluminum or a metal screen might be placed over the source and connected to the shell of the counter to provide a direct leakage path and rapid dissipation of static electricity.)

Cyclotron-produced Radioisotopes

A significant number of radioisotopes either cannot be produced by a nuclear reactor or cannot be produced to meet specifications for many scientific applications. To meet these needs, certain useful cyclotron radioisotopes may be obtained from AEC facilities.

Cyclotron irradiation time is presently obtained from

Massachusetts Institute of Technology
University of Pittsburgh
Washington University (St. Louis)
University of California (Berkeley)

The chemical processing of the bombarded targets is carried out at Oak Ridge National Laboratory in facilities already provided for handling reactor-produced isotopes. Allocation of these materials is made by the Isotopes Division under the same procedure as for reactor-produced materials.

The processed isotopes available under this program are given in the following table.

Catalog item No.	Isotope	Half-life	Radiation		Price per mc
			Beta	Gamma	
4-Cy	Beryllium 7	54.5d	K	0.479	$ 75.00
11-Cy	Sodium 22	2.6y	~1.8 β^+		100.00
			0.575 β^+	1.28	
25-Cy	Manganese 54	310d	K	0.835	100.00
			1.0(<0.1%)		
26-Cy	Iron 59	46.3d	0.26(50%)	1.3	150.00
	(free of Fe 55)		0.46(50%)	1.1	
27-Cy	Cobalt 57	270d	0.26 β^+	0.014	75.00
				0.119	
				0.131	
30-Cy	Zinc 65	250d	K(46%)	1.1	100.00
	(free of Zn 69)		K(51%)	None	
			0.32 β^+(~3%)		
33-Cy	Arsenic 73	76d	K	0.052	75.00
53-Cy	Iodine 125	56d	K		400.00

Occasionally an investigator will need a cyclotron isotope other than those listed above. Although it would not be possible to furnish separated items, an unprocessed cyclotron target may be obtained. Such targets are sold at a cost of $11.00 per each hour the target is submitted to the cyclotron beam.

Information concerning chemical forms, specific activities, and unprocessed targets will be provided on request to the Oak Ridge National Laboratory.

1184978

RADIOISOTOPE-LABELED COMPOUNDS

Registry of Isotope-labeled Compounds

As the use of isotopes has become more widespread, interest in the availability of isotope-labeled compounds has increased accordingly. In order to encourage the wider distribution of such compounds, the Isotopes Division has established a Registry of Isotope-labeled Compounds to maintain current information on their availability.

The Registry will give users an opportunity (1) to find out whether or not a specific compound is available and the supplier, and (2) to inform other users of a specific compound which is available for transfer, with or without charge. Persons who wish to register available compounds should inform the Isotopes Division, stating

Compound (name and formula)	Quantity
Position of label	Package sizes
Specific activity	Charges (if any)

Convenient post cards are included with this catalog which may be used to register available compounds or to make inquiry concerning the availability of compounds desired.

The Registry will include compounds available from off-Commission laboratories both private and commercial. In addition, isotope-labeled compounds produced in contractor-operated laboratories of the Commission will be registered and made available for distribution. However, when a private firm registers a compound also produced in Commission facilities, the Commission will withhold its material from general distribution.

A complete list of isotope-labeled compounds registered with the Isotopes Division will be published and distributed at least semiannually.

1184979

2. Stable Isotopes

HYDROGEN 2 (DEUTERIUM)

Deuterium gas and deuterium oxide (heavy water) are distributed on allocation from the Isotopes Division by

Stuart Oxygen Co.
351 California Street
San Francisco 4, Calif.

The abundance of the heavy hydrogen isotope, H 2, in the deuterium is approximately 99.8 per cent. Deuterium gas is processed from the oxide by Stuart Oxygen Co. and will meet the above specification within 0.3 per cent.

The price schedule for an order specified to be delivered to an applicant at one time is as follows:

Deuterium Oxide (D_2O)

1-g ampules		5- or 10-g ampules		25-g ampules		100-g ampules	
No. grams	Price per gram	No. grams	Price per gram	No. grams	Price per gram	No. grams	Price per gram
1	$1.00	5-20	$0.75	25-75	$0.50	100	$0.40
		>25	0.55	100-175	0.45	200-400	0.35
				200-475	0.40	500-900	0.30
				>500	0.35	1000-4900	0.25
						>5000	0.20

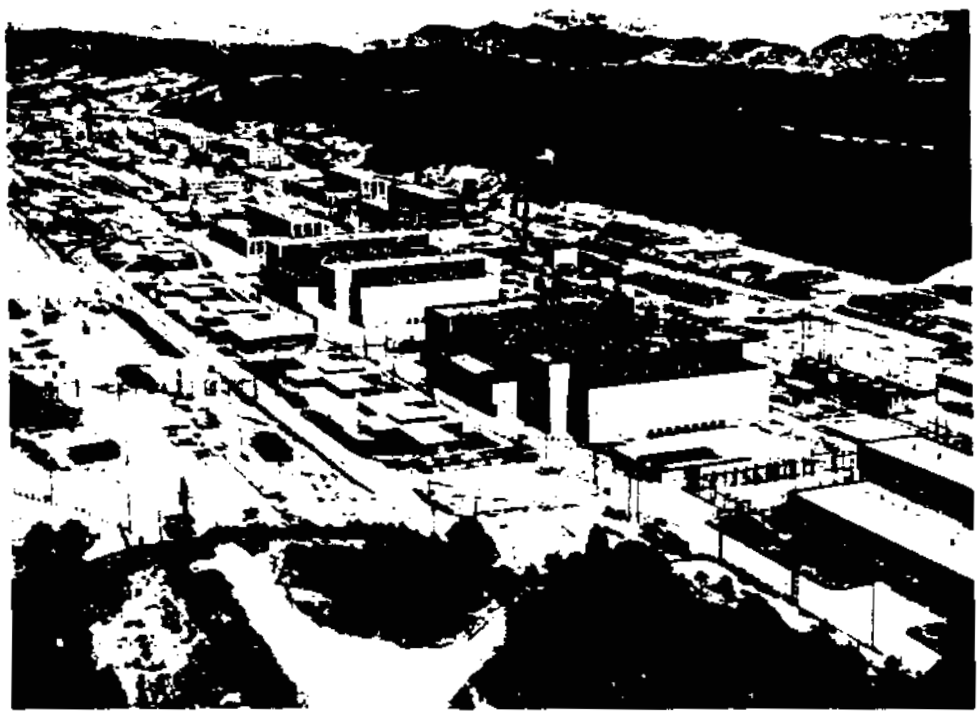
The Commission makes no guarantee that the deuterium oxide distributed is free from pyrogenic materials.

Deuterium Gas (D_2)

The price of deuterium gas is $1.00 per liter, normal temperature and pressure, for the first 100 liters and $0.80 per each additional liter. Gas will be shipped as nearly as possible in the following types of standard medical gas cylinders:

Liters (NTP)	Type of cylinder	Psi (approx.)
25	AA	700
50	B	700
75	C	500
100	C	700
100	D	500

1184980



Oak Ridge National Laboratory, Y-12 Area.

A charge will be made of $9.60 for each AA or B cylinder and $10.00 for each C or D cylinder. The charge will be refunded if the cylinder is returned in good condition to Stuart Oxygen Co. within three months from the date of the original shipment.

Express or postage will be added to the invoice. Oxide may be shipped parcel post or air express; gas must be shipped by rail freight or express. (The latter cannot be shipped by parcel post or air express.)

Deuterated Compounds

Deuterated compounds are not available directly from U. S. Atomic Energy Commission facilities. However, compounds may occasionally be purchased from commercial laboratories. Information concerning compounds available and the names of the suppliers may be obtained from the Isotopes Division. Suppliers are urged to advise the Isotopes Division of deuterated compounds which they have for sale or transfer.

HELIUM 3

Helium 3 is distributed on allocation from the Isotopes Division by Oak Ridge National Laboratory.

In view of limited production, the Isotopes Division can generally accept applications only for quantities up to 1 cc of gaseous He 3 (greater than 80 per cent purity) at standard temperature and pressure. In cases of very special need, requests for quantities of He 3 up to 3 cc may be approved.

1184981

Applicants should note that thus far He 3 has only been packaged in flasks containing 1 and 3 cc. The price of He 3 in these quantities has been set at $200.00 per cubic centimeter (STP). The material will be shipped by Railway Express collect. A detailed analysis will accompany all shipments.

BORON 10

Boron 10 is distributed on allocation from the Isotopes Division by Oak Ridge National Laboratory.

Boron 10 is available in the form of the solid complex, boron trifluoride–calcium fluoride, and also as elemental B 10.

Boron Trifluoride Complex ($BF_3 \cdot CaF_2$)

This isotope contains 6.9 per cent elemental boron, of which 96 per cent is B 10, corresponding to an enrichment of about 4.8 times normal.

Approximately 6.5 g of $BF_3 \cdot CaF_2$ is needed to obtain 1 liter of BF_3 at standard temperature and pressure (assuming 100 per cent liberation). The boron trifluoride may easily be released as a gas by heating to temperatures above 260°C in a vacuum. Organic vapors and air released from the complex during heating will be present in the BF_3 and will have to be removed in processing material for use in neutron counters.

The price of $BF_3 \cdot CaF_2$ complex is $2.00 per gram, postage prepaid. Standard units of 1, 5, 10, and 50 g have been packaged in glass containers with moistureproof plastic screw tops. All requirements will be filled in single units or multiples of these standard sizes.

Elemental Boron 10

Elemental B 10 is in the form of a powder with particle size the order of 200 mesh. It is composed of 98 per cent boron with 2 per cent impurities of iron, magnesium, and silicon. The boron contains approximately 96 per cent B 10.

Only a limited quantity of elemental B 10 is available. The applicant should state the amount required for the proposed investigation and should clearly justify the expenditure of the material. Allocation approvals will be based upon the information furnished.

The price of the elemental B 10 is $15.00 per gram, postage prepaid. It is packaged in quantities of 1 g or more.

BORON 11

Boron 11 is distributed on allocation from the Isotopes Division by the Oak Ridge National Laboratory.

Boron 11 will be packaged for shipment in the form of the solid complex, boron trifluoride–calcium fluoride. The complex contains 10 per cent or less elemental boron, of which approximately 89 per cent is B 11, corresponding to a B 10 content 60 per cent of its normal abundance.

Units of 1, 5, 10, and 50 g are packaged in glass containers with moistureproof plastic screw tops. Orders will be filled in single units or multiples of these standard sizes.

The price of B 11 enriched $BF_3 \cdot CaF_2$ is $1.00 per gram, postage prepaid, independent of quantity.

OXYGEN 18

Oxygen 18 is distributed on allocation from the Isotopes Division by

Stuart Oxygen Co.
351 California Street
San Francisco 4, Calif.

1184982

Oxygen 18 is available in two forms: enriched water H_2O^{18} and enriched heavy water D_2O^{18}. Unless otherwise needed by the applicant, O 18 will be allocated in the form H_2O^{18}. The O 18 isotopic enrichment for either compound is about 7.7 times normal, corresponding to a concentration of 1.54 mole per cent.

The price schedule for an order of H_2O^{18} or D_2O^{18} to be delivered at one time is as follows:

1-g ampules		5- or 10-g ampules		25-g ampules		100-g ampules	
No. grams	Price per gram	No. grams	Price per gram	No. grams	Price per gram	No. grams	Price per gram
1	$1.00	5-20	$0.75	25-75	$0.50	100	$0.40
		>25	0.55	100-175	0.45	200-400	0.35
				200-475	0.40	500-900	0.30
				>500	0.35	1000-4900	0.25
						>5000	0.20

The Commission makes no guarantee that the O 18 distributed is free from pyrogenic materials.

Express or postage charges will be added to the invoice. Both H_2O^{18} and D_2O^{18} may be shipped by parcel post or air express.

ELECTROMAGNETICALLY CONCENTRATED ISOTOPES

Electromagnetically concentrated stable isotopes are distributed on allocation from the Isotopes Division by the Y-12 Plant, Oak Ridge National Laboratory.

The quantities which have been concentrated are large compared with those obtained with laboratory mass spectrographs; in general, the amounts will be within the range of 1 mg to 1 g.

The isotopic enrichment attainable by the electromagnetic process varies widely from element to element and isotope to isotope. For an element consisting of two or more isotopes, the abundance of all isotopes in the sample will be somewhat altered from the natural isotopic abundance of that element. Complete isotopic abundance data and a spectrochemical analysis will be furnished with each sample shipped.

Because of the limited supply, electromagnetically separated isotopes are available only on a loan basis. A "pool" of stable isotopes has been established from which conservative amounts may be withdrawn for research purposes. Investigations which do not use up the material or dilute its enrichment will be given highest priority on allocation.

Applications for electromagnetically concentrated stable isotopes should contain the following additional information on either Form AEC-100 or an attached sheet:

1. Weight in milligrams of the element not the isotope
2. Concentration desired
3. Minimum concentration acceptable
4. Approximate delivery date
5. Number of months for which loan is desired
6. Estimated quantity to be returned
7. Chemical form and dilution of isotope to be returned

Please note that a completed form, Agreement for Loan of Electromagnetically Concentrated Stable Isotopes, is required prior to approval of the requests.

A service and rental fee of $50.00 is charged for each sample, shipping charges prepaid. Charges are not made for the isotopes themselves; the fee includes only partial costs of handling applications, analyses, shipment, and other incidental costs.

The undiluted isotopic material, whether in the original compound or another form is to be returned to the Commission at the end of the agreed period of loan. Diluted material may be returned, but it should be accompanied by a statement giving details of chemical treatment which the sample has

1184983

undergone, the chemical form in which the isotope is being returned, the quantity returned, and the dilution of the isotope. A statement covering expended material must also be furnished to the Isotopes Division.

It is planned to investigate the separation of stable isotopes of most elements and to increase yields of those isotopes previously concentrated. However, specific isotopes will not be producible to the applicant's order, and the date cannot be estimated when further quantities of a given isotope will be concentrated.

The following table lists those isotopes which have been concentrated by the electromagnetic process. The quantity of material listed in column 5 represents the maximum element weight that may, in general, be obtained per allocation. If no quantity is given in column 5, the item is at this time out of stock. In this case, the enrichment and product form, if given, correspond to previously separated materials. This list represents current data; supplementary information may be obtained through correspondence with the Isotopes Division.

Atomic No.	Element and isotope	Natural abundance in element, %	Abundance in enriched element, %	Maximum available element weight, Mg	Product form
3	Li 6	7.3	95.2	50	Li_2SO_4
	Li 7	92.7	98.7–99.89	2,000	Li_2SO_4
5	B 10	18.83	*	50	H_3BO_3
	B 11	81.17	*	100	H_3BO_3
12	Mg 24	78.98	99.5	2,000	MgO
	Mg 24	78.98	98.36	192	MgO
	Mg 25	10.05	86.8	205	MgO
	Mg 25	10.05	92.33	500	MgO
	Mg 26	10.97	95.9	210	MgO
	Mg 26	10.97	98.12	200	MgO
16	S 32	95.06	97.9	100	S
	S 32	95.06	*	1,000	CdS
	S 33	0.74	5.54		S
	S 33	0.74	†		S
	S 34	4.18	20.65		S
	S 34	4.18	†		
	S 36	0.0136	0.319		S
	S 36	0.0136	†		
17	Cl 35	75.4	92.4		AgCl
	Cl 37	24.6	65.6	200	AgCl
19	K 39	93.08	99.5	500	$KClO_4$
	K 39	93.08	99.74–99.94	1,000	KCl
	K 40	0.012	0.17	288	KCl
	K 40	0.012	0.40	100	KCl
	K 40	0.012	7.12–8.1		KCl
	K 41	6.91	92.9	65	$KClO_4$
	K 41	6.91	91.61	100	K_2SO_4
	K 41	6.91	98.94	300	KCl

*Analysis incomplete.
†Refinement incomplete.

1184984

Atomic No.	Element and isotope	Natural abundance in element, %	Abundance in enriched element, %	Maximum available element weight, mg	Product form
20	Ca 40	96.92	98.6–99.97	150	CaO
	Ca 40	96.92	99.78	3,000	$CaCO_3$
	Ca 42	0.64	28.3	200	$CaCO_3$
	Ca 43	0.13	†		
	Ca 44	2.13	85.4–91.9	100	$CaCO_3$
	Ca 46	0.0032	†		
	Ca 48	0.179	†		
22	Ti 46	7.95	•	200	TiO_2
	Ti 47	7.75	82.05	31	TiO_2
	Ti 47	7.75	•	500	TiO_2
	Ti 48	73.45	99.23	100	TiO_2
	Ti 48	73.45	•	3,000	TiO_2
	Ti 49	5.51	77.62	37	TiO_2
	Ti 49	5.51	•	25	TiO_2
	Ti 50	5.34	84.69		TiO_2
	Ti 50	5.34	•	25	TiO_2
24	Cr 50	4.41	41.2	100	Cr_2O_3
	Cr 50	4.41	†		
	Cr 52	83.46	99.1	100	Cr_2O_3
	Cr 52	83.46	†		
	Cr 53	9.54	92.1	18	Cr_2O_3
	Cr 53	9.54	†		
	Cr 54	2.61	61.0–83.1		Cr_2O_3
	Cr 54	2.61	†		
26	Fe 54	5.90	39.0–55.47	300	Fe_2O_3
	Fe 54	5.90	34.47	10,000	Fe_2O_3
	Fe 54	5.90	84.3–93.27	100	Fe_2O_3
	Fe 56	91.52	97.42–99.7	50,000	Fe_2O_3
	Fe 57	2.245	51.91–55.53	500	Fe_2O_3
	Fe 57	2.245	74.6–87.29	200	Fe_2O_3
	Fe 58	0.33	42.0	25	Fe_2O_3
	Fe 58	0.33	34.8	50	Fe_2O_3
28	Ni 58	67.76	99.3	300	NiO
	Ni 58	67.76	92.7	1,000	NiO
	Ni 60	26.16	87.1–94.4	300	NiO
	Ni 60	26.16	97.7	50	NiO
	Ni 61	1.25	72.2–80.9	25	NiO
	Ni 62	3.66	91.2–94.7	20	NiO
	Ni 64	1.16	64.2–97.4		NiO

*Analysis incomplete.
†Refinement incomplete

1184985

Atomic No.	Element and isotope	Natural abundance in element, %	Abundance in enriched element, %	Maximum available element weight, mg	Product form
29	Cu 63	69.09	97.0 - 99.4	3,000	CuO
	Cu 65	30.91	98.16	2,000	CuO
30	Zn 64	48.87	83.8	100	ZnO
	Zn 64	48.87	•	1,000	ZnO
	Zn 66	27.62	78.4	200	ZnO
	Zn 66	27.62	•	1,000	ZnO
	Zn 67	4.12	56.0	50	ZnO
	Zn 67	4.12	•	500	ZnO
	Zn 68	18.71	93.9	18	ZnO
	Zn 68	18.71	•	1,000	ZnO
	Zn 70	0.69	32.0	25	ZnO
	Zn 70	0.69	•	100	ZnO
31	Ga 69	60.2	98.42	1,000	Ga_2O_3
	Ga 71	39.8	98.08	200	Ga_2O_3
32	Ge 70	20.55	88.1	100	GeO_2
	Ge 72	27.38	89.2	200	GeO_2
	Ge 73	7.61	68.9		GeO_2
	Ge 74	36.74	95.2	500	GeO_2
	Ge 76	7.67	79.3	19	GeO_2
34	Se 74	0.96	12.08	100	Se
	Se 76	9.12	41.5 - 57.4	500	Se
	Se 77	7.50	49.4 - 58.4	500	Se
	Se 78	23.61	72.3 - 82.56	500	Se
	Se 80	49.96	91.7 - 94.6	1,000	Se
	Se 82	8.84	51.6 - 52.36	300	Se
35	Br 79	50.57	86.98	100	AgBr
	Br 81	49.43	96.81	100	AgBr
38	Sr 84	0.56	63.68	25	$SrSO_4$
	Sr 86	9.86	89.02	300	$Sr(NO_3)_2$
	Sr 87	7.02	60.02	500	$SrCO_3$
	Sr 88	82.56	98.9 - 99.67	200	$Sr(NO_3)_2$
40	Zr 90	51.46	95.6 - 98.0	2,000	ZrO_2
	Zr 91	11.23	75.1 - 86.89	300	ZrO_2
	Zr 92	17.11	89.8 - 92.7	300	ZrO_2
	Zr 94	17.40	80.9 - 82.1	100	ZrO_2
	Zr 96	2.8	89.48	50	ZrO_2
42	Mo 92	15.05	92.07 - 95.5	50	MoO_3
	Mo 94	9.35	79.1	50	MoO_3
	Mo 95	15.78	80.75 - 88.0	500	MoO_3
	Mo 96	16.56	85.94 - 90.6	500	MoO_3
	Mo 97	9.60	75.4 - 77.97	500	MoO_3
	Mo 98	24.0	89.9 - 96.3	500	MoO_3
	Mo 100	9.68	90.2 - 93.0	25	MoO_3

*Analysis incomplete.

1184986

Atomic No.	Element and isotope	Natural abundance in element, %	Abundance in enriched element, %	Maximum available element weight, mg	Product form
47	Ag 107	51.35	90.26	300	AgCl
	Ag 107	51.35	98.96	39	AgCl
	Ag 109	48.65	92.16	300	AgCl
48	Cd 106	1.22	32.9	17	CdO
	Cd 108	0.89	14.2	100	CdO
	Cd 108	0.89	24.8	25	CdO
	Cd 110	12.43	55.8 – 70.0	500	CdO
	Cd 111	12.86	64.5	1,000	CdO
	Cd 112	23.79	79.3 – 83.5	1,000	CdO
	Cd 113	12.34	54.1	500	CdO
	Cd 114	28.81	79.52	96	CdO
	Cd 114	28.81	94.2	1,000	CdO
	Cd 116	7.66	24.01	200	CdO
	Cd 116	7.66	71.2	100	CdO
49	In 113	4.16	14.2	500	In_2O_3
	In 113	4.16	16.8 – 22.8	200	In_2O_3
	In 115	95.84	99.6 – 99.9	3,000	In_2O_3
50	Sn 112	1.01	45.5		SnO_2
	Sn 112	1.01	•	50	SnO_2
	Sn 114	0.68	32.7		SnO_2
	Sn 114	0.68	•	50	SnO_2
	Sn 115	0.35	12.1		SnO_2
	Sn 115	0.35	•	100	SnO_2
	Sn 116	14.28	43.2 – 74.5	100	SnO_2
	Sn 116	14.28	•	2,000	SnO_2
	Sn 117	7.67	75.3		SnO_2
	Sn 117	7.67	•	2,000	SnO_2
	Sn 118	23.84	69.3	918	SnO_2
	Sn 118	23.84	84.6 – 90.1	500	SnO_2
	Sn 118	23.84	•	3,000	SnO_2
	Sn 119	8.68	64.4 – 78.5	75	SnO_2
	Sn 119	8.68	•	2,000	SnO_2
	Sn 120	32.75	53.6 – 95.4	1,000	SnO_2
	Sn 120	32.75	•	5,000	SnO_2
	Sn 122	4.74	42.9	20	SnO_2
	Sn 122	4.74	•	5,000	SnO_2
	Sn 124	6.01	83.1	40	SnO_2
	Sn 124	6.01	•	400	SnO_2
51	Sb 121	57.25	97.7	25	Sb
	Sb 123	42.75	95.6	300	Sb

*Analysis incomplete.

1184987

Atomic No.	Element and isotope	Natural abundance in element, %	Abundance in enriched element, %	Maximum available element weight, mg	Product form
52	Te 120	0.090	22.3	20	Te
	Te 122	2.47	77.8	19	Te
	Te 122	2.47	86.24	100	Te
	Te 123	0.89	60.91	50	Te
	Te 124	4.74	72.5 – 83.9	50	Te
	Te 124	4.74	76.47	200	Te
	Te 125	7.03	40.5	264	Te
	Te 125	7.03	81.65	200	Te
	Te 126	18.72	79.0 – 93.2	1,000	Te
	Te 128	31.75	82.32 – 91.8	1,000	Te
	Te 128	31.75	94.4	200	Te
	Te 130	34.27	93.0	3,000	Te
	Te 130	34.27	78.23	1,000	Te
56	Ba 130	0.101	16.0		$BaCO_3$
	Ba 132	0.097	7.43		$BaCO_3$
	Ba 134	2.42	51.39	25	$BaCO_3$
	Ba 135	6.59	67.32	200	$BaCO_3$
	Ba 136	7.81	50.02	150	$BaCO_3$
	Ba 137	11.32	38.98	500	$BaCO_3$
	Ba 138	71.66	98.04	300	$BaCO_3$
57	La 138	0.089	0.597	300	La_2O_3
	La 139	99.911	99.96	3,000	La_2O_3
58	Ce 136	0.193	16.6		CeO_2
	Ce 136	0.193	8.94	50	CeO_2
	Ce 138	0.250	8.9		CeO_2
	Ce 138	0.250	4.42	100	CeO_2
	Ce 140	88.48	98.5 – 99.25	2,000	CeO_2
	Ce 142	11.07	84.42 – 87.4	500	CeO_2
60	Nd 142	27.13	*	500	Nd_2O_3
	Nd 143	12.20	*	300	Nd_2O_3
	Nd 144	23.87	*	400	Nd_2O_3
	Nd 145	8.30	*	200	Nd_2O_3
	Nd 146	17.18	*	300	Nd_2O_3
	Nd 148	5.72	†		
	Nd 150	5.60	†		
62	Sm 144	3.16	72.13	75	Sm_2O_3
	Sm 147	15.07	81.63	50	Sm_2O_3
	Sm 148	11.27	76.01	300	Sm_2O_3
	Sm 149	13.84	71.53	300	Sm_2O_3
	Sm 150	7.42	74.09	200	Sm_2O_3
	Sm 152	26.63	89.9	1,000	Sm_2O_3
	Sm 154	22.53	92.10	500	Sm_2O_3

*Analysis incomplete.
†Refinement incomplete.

1184988

Atomic No.	Element and isotope	Natural abundance in element, %	Abundance in enriched element, %	Maximum available element weight, mg	Product form
74	W 180	0.126	9.0		WO_3
	W 180	0.126	•	100	WO_3
	W 182	26.31	91.58	400	WO_3
	W 182	26.31	94.25	100	WO_3
	W 182	26.31	•	2,000	WO_3
	W 183	14.28	82.01 – 86.21	200	WO_3
	W 184	30.64	91.14 – 95.72	100	WO_3
	W 186	28.64	97.17 – 97.94	200	WO_3
75	Re 185	37.07	85.38	500	Re
	Re 187	62.93	98.22	300	Re
80	Hg 196	0.15	1.46 – 1.90	50	Hg
	Hg 196	0.15	8.44	10	Hg
	Hg 198	10.1	53.37 – 54.35	100	Hg
	Hg 198	10.1	66.11	50	Hg
	Hg 198	10.1	79.11	25	Hg
	Hg 199	17.0	62.51	100	Hg
	Hg 199	17.0	72.1 – 73.9	10	Hg
	Hg 199	17.0	68.0	40	Hg
	Hg 200	23.3	64.66 – 74.9	500	Hg
	Hg 200	23.3	80.85 – 91.39	100	Hg
	Hg 201	13.2	51.48 – 62.48	100	Hg
	Hg 201	13.2	71.8	20	Hg
	Hg 202	29.6	98.06 – 98.3	20	Hg
	Hg 202	29.6	75.75 – 97.33	100	Hg
	Hg 204	6.7	30.07	363	Hg
	Hg 204	6.7	42.91 – 89.17	100	Hg
81	Tl 203	29.52	34.1 – 86.0	500	Tl_2O_3
	Tl 205	70.48	90.5 – 98.7	1,000	Tl_2O_3
82	Pb 204	1.37	25.7	500	PbO
	Pb 206	25.15	71.3	200	$PbCrO_4$
	Pb 207	21.11	48.2 – 66.8	500	$PbCrO_4$
	Pb 207	21.11	•	1,000	PbO
	Pb 208	52.38	82.1 – 92.1	100	$PbCrO_4$
	Pb 208	52.38	•	3,000	PbO
	Pb 208	52.38	95.8	50	$PbSO_4$

*Analysis incomplete.

1184989

3. Outlines of Procedures for Procurement of Isotopes

RADIOISOTOPES

The procurement, delivery, possession, use, transfer, and disposal of radioisotopes are governed by Federal regulations. Regulations now in effect are reprinted in Sec. 8 of this catalog. Briefly, the procedure for the procurement of radioisotopes is as follows:

1. Applications for radioisotopes or irradiation services must be submitted to the Isotopes Division on Application for Radioisotope Procurement, Form AEC-313. After review and approval of the application, the Isotopes Division will issue Authorization for Radioisotope Procurement, Form AEC-374.

2. To obtain the isotopic material or service, the original copy of Form AEC-374, together with a purchase order if required, should be sent to the supplier. Materials cannot be shipped, and irradiations cannot be performed until the authorization has been received by the supplier. Arrangements concerning production, shipment, and payment are made directly between the applicant and the supplier.

An authorization issued for a specific quantity of a specific radioisotope for use in a specific research project is referred to as a "limited authorization." A limited authorization expires six months after date of issue unless the time is extended by the Isotopes Division.

It is necessary that an applicant meet special conditions when he applies for (1) a general authorization for use of radioisotopes in research and development, (2) radioisotopes for field and industrial uses, (3) radioisotopes for use in human beings, and (4) radioisotopes free of production costs for cancer research. The conditions are described in detail below.

General Authorizations for Procurement of Radioisotopes

An institution which processes a large number of applications each year will facilitate its procurement of radiomaterials by applying for a General Authorization. A standard application form adapted for a General Authorization may be obtained from the Isotopes Division on request.

A General Authorization will

1. Permit the approved applicant to use radioisotopes at a specified location for any research and development activity*

2. Permit the approved applicant to obtain from any supplier any available form and quantity of any radioisotope distributed on authorization or approval of the Commission

3. Be effective for a full calendar or fiscal year. (The expiration date on a General Authorization will be either June 30 or December 31 of each year. The initial application may be made at any time; application for renewal of a General Authorization should be made well in advance of the expiration date.)

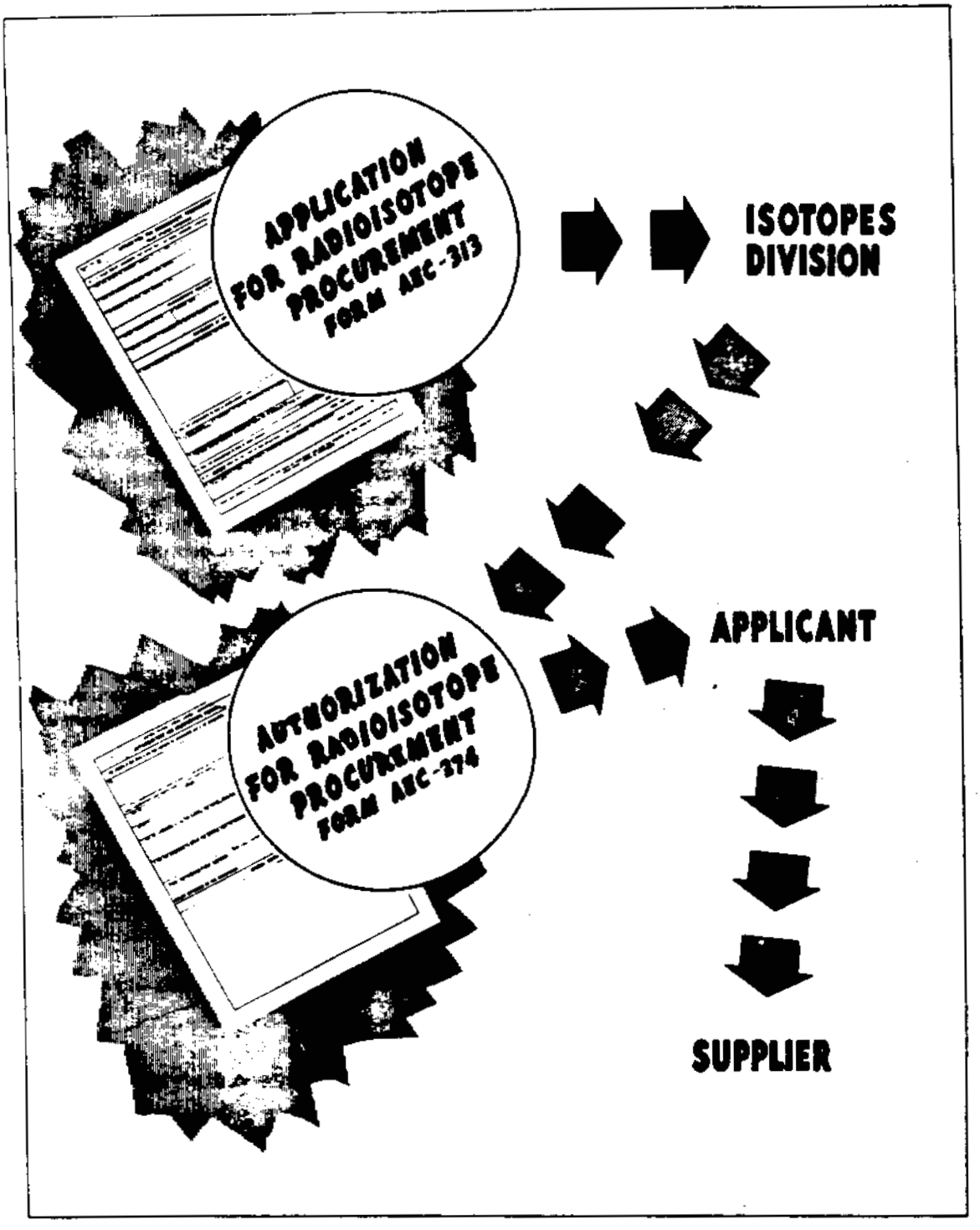
The conditions under which an application for a General Authorization will be considered are as follows:

1. The applicant, within the preceding 12-month period, has received at least twenty Authorizations for Procurement of Radioisotopes for use in research and development activities.

---

*Section 18(3) of the Atomic Energy Act of 1946 defines research and development as "theoretical analysis, exploration, and experimentation and the extension of investigative findings and theories of a scientific or technical nature into practical application for experimental and demonstration purposes, including the experimental production and testing of models, devices, equipment, materials, and processes."

1184990


APPLICATION FOR RADIOISOTOPE PROCUREMENT FORM AEC-313
ISOTOPES DIVISION
AUTHORIZATION FOR RADIOISOTOPE PROCUREMENT FORM AEC-374
APPLICANT
SUPPLIER

1184991

2. The applicant has established an institutional isotope committee which will review and approve, in advance of purchase of radioisotopes, proposals for use of radioisotopes to be made in the institution to assure that

a. The investigator is qualified to use radiomaterials safely.

b. Facilities are available to the investigator for safe use of radioisotopes.

c. The proposed use is safe. (The Commission generally will not evaluate the scientific merit of a proposed investigation.)

(See Sec. 6 for suggestions concerning an institutional isotope committee.)

3. The applicant has appointed a radiological safety officer to be responsible for

a. Keeping records of the receipt, storage, use, transfer, and disposal of radioisotopes obtained by the institution

b. Accomplishing all radiation monitoring and health protection, including observance of such safety standards as may be established by the Commission

c. Reporting to the Isotopes Division all shipments or transfers made from the institution

(See Sec. 6 for suggestions concerning a radiological safety officer.)

4. The applicant has adequate radiation monitoring equipment.

Applicant institutions should be sure to include with the application complete statements concerning the qualifications of the radiological safety officer and of the members of the institutional isotope committee. It is recommended that the applicant include any other pertinent information in support of the application.

Before making a radioisotope shipment, a supplier requires evidence that an institution holds an authorization for procurement. The Isotopes Division will issue six General Authorizations on Form AEC-374 to each approved applicant. A single serial number will be assigned to each General Authorization; copies will be designated by a suffix (A, B, C, etc.). If an applicant finds it necessary to obtain radiomaterials from more than six suppliers during the year, the Isotopes Division will issue additional copies of a General Authorization on request.

If requested, a representative of the Isotopes Division will call on an institution which is interested in obtaining a General Authorization. He will be prepared to confer with local authorities on arrangements for setting up the required organization and procedures.

A member of the Isotopes Division Advisory Field Service staff will visit, at least once a year, each institution holding a General Authorization. A report of satisfactory control of radioactive materials and radiation hazards will be considered by the Isotopes Division in approving subsequent applications for annual renewal of a General Authorization.

Field and Industrial Uses of Radioisotopes

The primary problem involved in field and industrial uses of radioisotopes is that of safety control and accountability. If a radioisotope is to be used under other than laboratory conditions, the plan should provide for long-term control of the activity. The amount of activity involved is an important consideration, as is the type of radiation emitted by the radioisotope in question. Furthermore, the likelihood of radiation exposure of persons who could have no knowledge of the presence of the radioactive material, or of its potential danger, must always be considered.

Field Uses. An application for use of a radioisotope in a field study should usually be supported by

1. A detailed outline of the experiment

2. A map of the area, showing topography

3. A full description of the distribution of the human population

4. A statement concerning the relation of the experimental area to watersheds from which domestic water supplies are collected

5. A description of the underground strata with reference to likelihood of movement of water and fixation of activity by mineral components

6. A statement regarding the degree of control which can and will be maintained over the experimental area.

1184992

Industrial Uses. Industrial applications of radioisotopes fall into three general groups.

1. Cases in which the activity is mounted in a device used to control industrial processes

2. Cases in which the activity is used in a process but does not appear in any product sold to the public

3. Cases in which the activity would be present in products sold to the public

In cases 1 and 2 the factors to be considered are much the same as those pertinent to use of radioisotopes in laboratories. If the activity is well shielded, otherwise controlled, and under the supervision of trained workers, the use would be considered feasible.

Case 3 raises the question as to the levels of beta and gamma activity which might be permitted in products sold to the public.

1. Beta-ray emitters. Proposals to incorporate beta-emitting radioisotopes in products offered for sale can be approved if (1) the radioactive substance is in insoluble form and incorporated permanently in inert material and (2) the product produces no more radiation than 0.3 rep per week at the surface.

2. Gamma-ray emitters. Products containing gamma emitters must meet the conditions outlined above for beta emitters. In addition, when products are stored, monitoring must be done to show that the radiation level is in accord with the limits stated in the handbook, Safe Handling of Radioisotopes, issued by the National Committee on Radiation Protection.

Radioisotopes Free of Production Costs for Cancer Research

All radioactive material normally available under the isotope-distribution program will be distributed, free of production costs, to qualified applicants providing the materials are to be used in cancer research. Sodium 24, P 32, and I 131 are also distributed free of production costs for use in routine or nonexperimental programs for the diagnosis and treatment of cancerous or allied diseases.

Cancer research is interpreted to include the following:

1. Investigation of the basic aspects of normal and abnormal cellular growth

2. The development and evaluation of therapeutic and diagnostic procedures for cancer and allied diseases

Considerable interest has been expressed concerning the use of Co 60 as a radiation source in the treatment of cancer. The use of Co 60 needles is not considered research unless the needles are of some unusual design or incorporate some unusual feature. Similarly, if multicurie sources of Co 60 are considered as substitutes for other sources of high-energy gamma or X rays for teletherapy units, the proposed use would be looked upon as cancer research only if the techniques to be employed departed from those already established for the gamma- or X-ray sources, or if a considerable program is to be undertaken with the unit on the biological effects of radiation.

Refer to the following subsection for details concerning the allocation policy for radioisotopes to be used in medicine.

Although radioactive materials distributed under the cancer program will be free of production charges, a handling charge of $10.00 will be made on each shipment to cover the cost of packaging, monitoring, accounting, and billing. Transportation charges will be paid by the applicant.

Suppliers who furnish materials to users authorized to receive radioisotopes without charge for production costs may apply to the Isotopes Division for replacement of the activity delivered. In case the radioisotope delivered has a half-life of less than 30 days, the supplier may request replacement of all activity including that required in the processing.

Allocation Policy for Radioisotopes for Use in Medicine

Owing to the potential health hazards associated with radioactivity, certain criteria have been set up for the authorization of radioactive substances to be used in human subjects.

1. Commission facilities do not guarantee the radioactive strength and quality of materials distributed nor that they are free from pyrogenic materials.

2. All applications for use of radioisotopes in human beings are subject to review by the Subcommittee on Human Applications of the Advisory Committee on Isotope Distribution.

1184993

The following general aims govern the distribution of radioactive materials for medical purposes:

1. To make radioisotopes available for diagnostic and therapeutic purposes where they are needed

2. To protect, as far as possible, patients from indiscriminate use of radioisotopes

3. To ensure that those planning to use the materials have adequate facilities for proper and safe handling.

Criteria for Medical Use. The following criteria for authorization are based on the general aims stated above.

1. Physicians using radioactive material must be associated with a medical research institution, hospital, clinic, or other medical organization possessing adequate facilities and which is in good standing with the local medical society. Facilities must be adequate for clinical care of the patient and assaying, safe handling, and disposal of radioactive materials.

2. The hospital or medical institution must appoint a local isotope committee to evaluate all proposals for therapeutic use of radioisotopes within that institution. (See Sec. 6 for suggestions concerning an institutional isotope committee.)

3. The scientifically trained individual who will use or directly supervise the use of material must be an accredited physician in good standing with the local medical society. The physician must have had previous clinical experience with radiation or radioactive materials or be directly collaborating with an individual possessing such training and experience.

Normal Adults. Administration of radioisotopes to humans should always be kept to the minimum amount required to accomplish the objective of the work. Applicants who desire to use radioisotopes (beta- and/or gamma-ray emitters) in normal adults should submit a statement of the results of animal experiments, or adequate reference to the literature, concerning the metabolism of the radiomaterials in the form administered. The dosage to the critical tissue (tissue of maximum concentration) should not exceed 0.3 rep per week from a single or repeated administration in normal adults when no therapeutic or diagnostic benefit to the patient can be reasonably anticipated.

Applications should include detailed statements concerning the following points:

1. The tissue of highest concentration and the relative concentration therein

2. The relative concentrations in the tissue of interest and particularly radiosensitive tissues, such as the gonads and hematopoietic system

3. The biological half-life of the radioisotope in the tissue of highest concentration, the tissue of interest, and the particularly radiosensitive tissues

Normal Children. In general, the use of radioisotopes in normal children is discouraged. However, proposals for such use will be considered provided the problem cannot be studied properly by other methods and provided the radiation dosage level in any tissue is low enough to be considered harmless. It should be noted that, in general, the amount of radioactive material per kilogram of body weight must be smaller in children than that required for similar studies in adults.

Normal Pregnancy. The use of radioactive materials in all normal pregnancies is strongly discouraged where no therapeutic benefit is to be derived.

Special Pathological Conditions. There may be instances in which the disease from which a patient is suffering permits the administration, for investigative purposes, of doses larger than those recommended above for use in normal subjects. Applications for such uses of radioisotopes will be given special consideration provided

1. Full responsibility for conduct of the work is assumed by a special committee of at least three competent physicians in the institution in which the work is to be done.

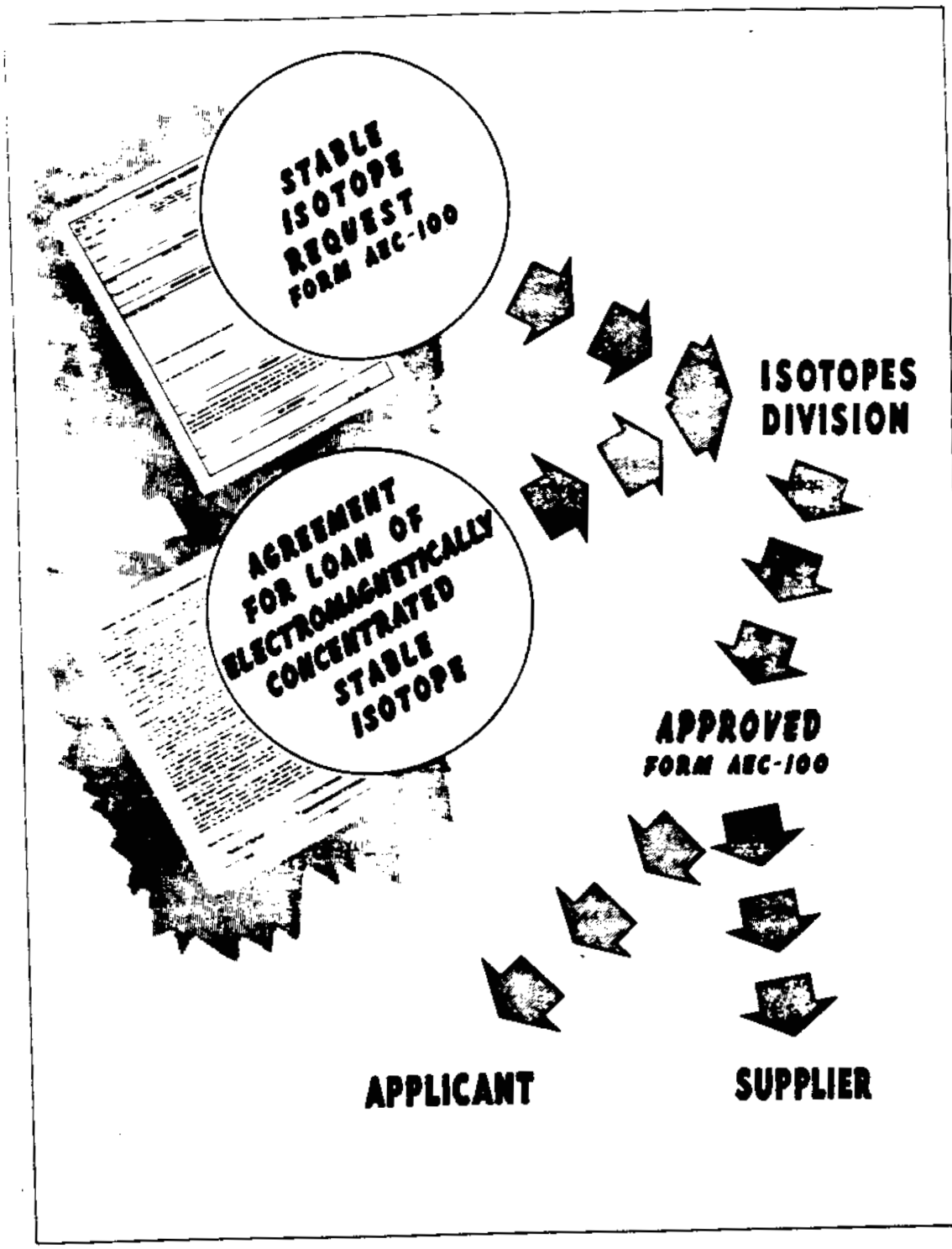
2. The subject has given his consent to the procedure.

3. There is no reasonable likelihood of producing manifest injury by the radioisotope to be employed.

Treatment of Polycythemia Vera and Chronic Myelogenous Leukemia. The use of P 32 for the treatment of polycythemia vera and chronic myelogenous leukemia by licensed physicians in good standing will be authorized provided

1. The applicant has a suitable survey instrument.

1184994


STABLE ISOTOPE REQUEST FORM AEC-100
AGREEMENT FOR LOAN OF ELECTROMAGNETICALLY CONCENTRATED STABLE ISOTOPE
ISOTOPES DIVISION
APPROVED FORM AEC-100
APPLICANT
SUPPLIER

1184995

2. The applicant obtains from a university medical school or university hospital a statement that he is qualified to use P 32 in treatment of these diseases; the medical school or hospital ... authorized user of P 32 in treatment of these diseases.

3. The P 32 activity is measured before use. The measurement should be performed by the university medical school or university hospital which certified the applicant's qualifications or a a radioisotope supplier qualified to make such measurements.

University medical schools or university hospitals are expected to state that applicants are qualified to use P 32 in the treatment of polycythemia vera or chronic myelogenous leukemia only if (1) the applicant's previous training and experience have equipped him to engage in this work, or (2) the applicant has observed or participated in the use of P 32 in the treatment of these diseases at the responsible institution.

Beta-ray Applicators. Beta-ray applicators are available for use by licensed physicians in good standing who are either qualified ophthalmologists or therapeutic radiologists qualified by training and experience to carry out the proposed program. No monitoring instruments or local isotope-committee endorsement will be required, nor need the applicant be affiliated with a hospital or clinic.

Before a beta-ray applicator is used, the applicant must receive from the manufacturer or from the National Bureau of Standards a certificate which states (1) the dosage rate of the applicator and (2) that there is no detectable leak of activity to the exterior. The applicator must be identified by the name of its manufacturer and its serial number. A copy of the certificate must be filed with the Isotopes Division.

Each 12 months the applicant must similarly file a certificate, executed by the manufacturer, stating that the applicator still exhibits no detectable leak of activity to the exterior.

The certificate is substituted for the usual requirement that applicants for radioisotopes possess certain radiation-detection equipment.

Manufacturers of beta-ray applicators should arrange for periodic inspection of all units and for replacement of units which leak activity.

Recommended Laboratory Facilities. A laboratory should be set aside for exclusive use in handling and chemical processing of radioisotopes.

There should be a separate room and equipment available for making measurements of radioactivity.

There should be available proper storage space for the isotopic material and for the special equipment that is used in the handling operations.

To coordinate the handling and measurement of the materials, it is often desirable to have a specially trained physicist make the necessary measurements and a radiochemist to perform handling operations. Quite often one individual is qualified to carry out both these functions.

Certificate of Compliance with Federal Food, Drug, and Cosmetic Act. It should be noted that regulations in effect under Section 595(i) of the Federal Food, Drug, and Cosmetic Act provide that, prior to distribution of a new drug in interstate commerce, the shipper must have a statement on file from the applicant certifying that the applicant has adequate facilities for the investigation and that such drug will be used solely by him or under his direction. Radioelements intended for drug use or investigation, whether for experimental animals or human beings, have been classified as new drugs.

STABLE ISOTOPES

Concentrated stable isotopes produced in plants and laboratories of the U. S. Atomic Energy Commission are distributed on a sale or loan basis as follows: Isotopes of elements which have been concentrated electromagnetically are available on a loan basis; all others are available through direct purchase.

Applications for these materials must be submitted on Request for Stable Isotope, Form AEC-100, to the Isotopes Division. Do not place a purchase order with the supplier until after receiving notice from the Isotopes Division that the request has been approved.

Agreement for Loan of Electromagnetically Concentrated Stable Isotope must be filed by an applicant who wishes to obtain isotopes concentrated by this process. Forms may be obtained from the Isotopes Division.

1184996

4. Health and Safety

Throughout the Atomic Energy Act of 1946 there are provisions relating to the safety and protection of health in the atomic energy program. For example, Section 5(c)(2) reads in part, "The Commission shall not distribute by-product material (radioisotopes) to any applicant who is not equipped to observe or fails to observe such safety standards to protect health as may be established by the Commission."

Any person who applies for and uses radioisotopes should be familiar with the problems of radiation control. The brief discussion on health and safety in this section includes several references to publications wherein may be found more detailed discussions of radiation-protection and safe-handling techniques. The technical staff of the Isotopes Division will furnish additional information on request.

NUCLEAR RADIATIONS

Nuclear radiations are of two general types: (1) particulate matter—the neutrons, alpha and beta particles—and (2) electromagnetic waves of extremely short wavelength—the gamma and X rays. Their basic characteristics may be tabulated as follows.

Alpha Particles—helium nuclei, comparatively large, positively charged particles, high ionization, low penetration. They are unable to penetrate the unbroken skin, but if an isotope liberating them is deposited within the body, they may cause extreme damage.

Beta Particles—electrons, comparatively large, negatively charged particles, moderate ionization, moderate penetration. At most, they will penetrate about 20mm of tissue.

Gamma Rays—photons of electromagnetic radiation emitted by the nucleus when it has excess energy, low ionization, high penetration. They are less damaging, quantity for quantity, than the above types of radiation, but because they penetrate deeply, they are a major problem.

Neutrons—uncharged, penetrating, highly damaging particles. Depending on their speed, they can penetrate several feet of matter.

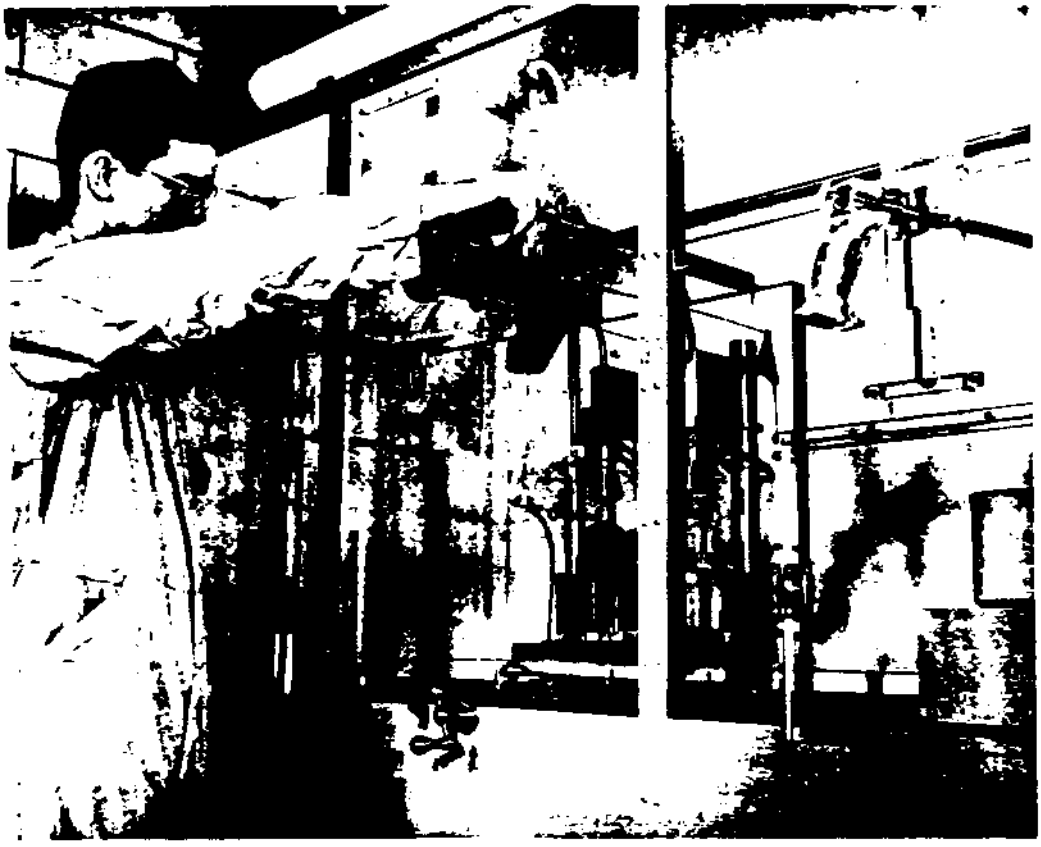
Nuclear radiations cause damage by ionization. Particles or rays disrupt the atoms and molecules of any substance they strike—air, concrete, steel, animal tissue. They cause atoms to divide into positive and negative parts (ions) and upset the delicate electrical balance of molecules.

Under the present program, only one alpha emitter (Po 210, catalog item 83, Table 2) and one neutron emitter (Sb-Be neutron source, catalog item 51D-P, Table 1) are available from Commission facilities. Therefore the radioisotope user is primarily concerned with control of beta and gamma radiations.

METHODS OF RADIATION CONTROL

In the presence of radiation, safety is maintained by shielding, by distance from the radioactive source, by time limits of exposure, or by a combination of the three. Protection from inhalation or ingestion of radioactive materials is accomplished by controlled ventilation that keeps dusts, gases, and vapors out of the air and by rigorous housekeeping to prevent and control radioactive contamination. Radiation monitoring equipment such as survey meters, ionization chambers, and film badges is used for additional protection of personnel working in areas where radioisotopes are used.

1184997



Bottling P 32 for shipment.

Broadly speaking, there are two methods of controlling wastes: (1) concentration and storage and (2) dilution and disposal. Gaseous and airborne materials may be controlled by filtration and dilution with air, short-lived radioactive liquids may be controlled by holding them until they decay to a safe level and by dilution with water, more dangerous or long-lived radioactive liquids may be controlled by concentration or evaporation to a solid state and holding in storage, and solid radioactive and contaminated materials may be controlled by burying under controlled conditions. See page 56 for information on special disposal services.

RADIATION UNITS USED IN HEALTH AND SAFETY MEASUREMENTS

Radiation dosage units are related to the roentgen, which applies to the ionizing effect of gamma and X rays. The units in use are as follows.

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

Roentgen equivalent physical (rep) is that dose of ionizing radiation which is capable of producing energy absorption of 93 ergs/g of tissue.

Roentgen equivalent mammal, or man, (rem) is that quantity of radiation which, when absorbed by mammalian tissue, produces an effect equivalent to the absorption by this tissue of 1 r of X or gamma radiation.

1184998

The physical equivalents are as given in the following table.

Radiation	Roentgen	Rep	Rem
Gamma or X ray	1	1	1
Beta		1	1
Neutron		1	10
Alpha		1	20

PERMISSIBLE LIMITS OF RADIATION EXPOSURE

In small amounts, radiation is a phenomenon of nature to which every living organism is subject; cosmic rays strike the earth everywhere, and materials such as radium in the earth's crust emit radiation. In large amounts, radiation is injurious to all living things. Before any systematic program of protection could be set up by the U. S. Atomic Energy Commission, it was necessary to decide what quantities and rates of exposure could safely be permitted.

External Exposure

Limits of continuous external radiation exposure were set by determining the day-after-day radiation exposure that experience and research indicated to be harmless and then applying a safety factor. The AEC program-wide rule at this time is that no worker shall receive more than a continuous dosage of 0.3 r in any one week; this amounts to about 15 r per year. The experts who set this figure believe that this rate of exposure would cause no damage even if continued throughout a lifetime.

"Exposure" as used here does not mean injury. Even exposure above the permissible limit does not signify injury so far as experience indicates. The least exposure that can cause minor blood changes, and which the body soon repairs, appears to be 25 to 50 r in a single quick dose. Thus the limit of 15 r per year provides for a safety factor for continuous exposure.

Internal Exposure

The permissible concentration of radioisotopes within the human body must be studied for each isotope because no two of them behave exactly alike. The pathological and genetical effects of radiation and the manner in which various elements and compounds are selectively concentrated in the various organs of the body are currently being studied. The problem is to determine the permissible concentration of radiomaterials in food, air, water, and general environment at levels innocuous to life. This work calls for continuing research. Because of the limited knowledge in this field, radioisotope users should take full precautions to prevent ingestion, inhalation, and absorption of radioactive materials.

Radiation protection committees of the United States, Canada, and the United Kingdom are cooperating in evolving standards for external, internal, and environmental radiation.

SAFE HANDLING OF RADIOISOTOPES

The Subcommittee on the Handling of Radioactive Isotopes and Fission Products of the National Committee on Radiation Protection, sponsored by the National Bureau of Standards, has prepared a pamphlet, Safe Handling of Radioactive Isotopes, National Bureau of Standards Handbook 42. Copies of Handbook 42, recommended to all radioisotope users, may be obtained from the Isotopes Division.

INSTRUMENTATION

All users of radioisotopes distributed by the U. S. Atomic Energy Commission are required to have adequate instrumentation for (1) measurement of activity and (2) monitoring to ensure safe radiation

1184999

Remote handling of radioisotopes at Oak Ridge National Laboratory.

levels and to locate and measure radiocontamination. The choice of instrument will depend on the type of radiation to be measured and the level of activity handled. The Radiation Instruments Branch, Washington Division of Biology and Medicine, has compiled a Radiation Instruments Catalog. The catalog gives information on the specifications and characteristics of various instruments and accessories used in radioisotope work, as well as the names of the manufacturers producing the equipment. Copies may be obtained (price $2.00) from

Office of Technical Services
Department of Commerce
Washington 25, D. C.

1185000

ADVISORY FIELD SERVICE

The Commission has a positive program of encouraging and developing health-safety standards in the use of the radioisotopes. The Advisory Field Service Branch of the Isotopes Division U. S. Atomic Energy Commission, has staff members trained in various scientific fields who serve as consultants to isotope users on health-safety facilities and practices. Through visits to laboratories, they give on-the-spot advice concerning radiation protection, monitoring and measuring equipment, standards of radioactivity, laboratory design, remote-handling equipment, decontamination, and radioactive-waste handling. However, isotope users should confer with private consultants for more detailed advice on planning and conducting their research investigations.

In addition to field visits, information service is available to isotope users on all problems concerning the safe handling of radioisotopes. Staff personnel will answer individual requests for specific information and will participate in seminar and lecture programs when permitted by travel schedules.

FILM-METER SERVICE FOR RADIATION MONITORING

Recipients of radioactive isotopes shipped from Oak Ridge National Laboratory may purchase film-badge service for radiation monitoring as follows:

M-1 Film Holders (each) $1.50

This is a stainless-steel badge-type holder with an alligator clip. It has a cadmium filter at one end enabling measurements to be made of both hard and soft radiation. All films processed at Oak Ridge National Laboratory must be used with this particular film holder owing to standardized processing techniques maintained by the Laboratory. Holders are not to be returned with the films.

M-2 Films (per lot of 20 packs) $6.00

The cost of processing is included. Each film pack contains two films. One film will measure gamma radiation from approximately 30 to 5000 mr. The second film will measure to approximately 20 r.

Calibrated control films are packaged with each lot of 20 films. All exposed films and the control pack must be returned for processing at the same time.

M-3 Plastic-ring Film Meters (per lot of 20) $8.00

A plastic-ring film meter, available from Oak Ridge National Laboratory, may be used as a beta- and/or gamma-ray monitoring device.

The ring film meter is made of a special, highly opaque plastic. It is adaptable for all use with film, resisting even out-of-door exposure to strong sunlight for reasonable lengths of time. The meter may be used as a finger ring, pinned to various parts of the clothing near the radiation sources to be monitored, or used in other ways where local radiation exposure is to be checked.

The cost includes ring film meters and processing. Each ring contains one film with a cadmium filter on each side of the film. A window is provided for soft radiation. The film will measure gamma radiation for approximately 30 to 5000 mr. Calibrated control films are packed with each lot of 20 rings.

All exposed ring film meters and control pack must be returned for processing at the same time.

Instructions for use are included in each shipment. All films are returned to the customer with interpretations.

Orders should be sent direct to Oak Ridge National Laboratory. Film-badge service is also available from several commercial firms.

1185001

REFERENCE SOURCES

Beta- and gamma-ray standard reference sources for use in calibrating counters and preparing working standards are available from the National Bureau of Standards. For further details, correspondence should be addressed to

National Bureau of Standards
Washington 25, D. C.
Attention: Radioactivity Section

Calibrated and uncalibrated reference sources may also be obtained from commercial suppliers. (See page 31 for availability of polystyrene sheets from Oak Ridge National Laboratory.)

SPECIAL SERVICE FOR DISPOSAL OF RADIOACTIVE WASTE PRODUCTS

Radioactive waste materials resulting from the use of reactor-produced radioisotopes may be returned to Commission facilities for disposal. The service has been initiated for the safe disposal of radioactive wastes which might endanger the public health and safety if they were handled by the conventional means of disposal available to the average radioisotope user.

Oak Ridge National Laboratory and the University of California Radiation Laboratory have been designated as receiving centers for radioactive waste materials. The Radiation Laboratory will receive wastes from users in the San Francisco Bay area only. Oak Ridge National Laboratory will accept wastes from users in all sections of the country. Materials which will be acceptable for disposal are

1. Radioisotopes which exhibit high radiotoxicity, as defined in National Bureau of Standards Handbook 42
2. Radioisotopes which cannot be reduced in specific activity by dilution with a stable element because of limited availability of the stable element
3. Radioisotopes with half-lives of 180 days or longer

All radioactive waste materials submitted to Oak Ridge National Laboratory or the Radiation Laboratory for disposal shall be packaged and labeled in accordance with Rules and Regulations of the Interstate Commerce Commission or Civil Air Regulations. In addition, the radioactive waste products must be prepared and shipments identified as specified by the receiving facility.

In general, a handling charge of $10.00 per unit or package will be made by the receiving facility. In cases where special handling is required, additional charges may be made. All shipping charges must be prepaid.

Isotopes users interested in this service should write to Oak Ridge National Laboratory or the University of California Radiation Laboratory for detailed information.

1185002

5. Technical Services

CONSULTATION

The Isotopes Division through correspondence is prepared to answer questions on methodology in many fields of isotope utilization, as well as inquiries concerning radiation protection, monitoring and measuring equipment, laboratory design and handling equipment, waste disposal, and radioactive standards. In addition, field visits are made to users and prospective users of radioisotopes to assist in matters pertaining to the safe handling of radioisotopes and to determine that they are being used in accordance with procedures stated in the applications.

Other types of consultation, particularly of an industrial nature, are not handled by the Isotopes Division. Such services are available from commercial firms and private consultants.

REPRINTS AND PUBLICATIONS

Information service on the techniques and uses of isotopes is maintained by the Isotopes Division, and applicants are urged to take advantage of this service. For the use of its staff and for maintenance of reference files, the Isotopes Division should receive six copies of all published papers on the results of research with isotopes (both stable and radioactive) obtained through its facilities.

The source of isotopic materials used in research should be acknowledged by a statement similar to the following: "The (name of material) used in this investigation was supplied by (name of supplier) on authorization from the Isotopes Division, U. S. Atomic Energy Commission." This information will materially assist the Isotopes Division in correlating applications with published reports.

As a part of its information program, the Isotopes Division will issue periodic bibliographies giving references to published work done with isotopes procured through Commission facilities. These bibliographies will be similar to the one in the report, Isotopes . . . A Three-year Summary of U. S. Distribution, and will be supplementary to it.

TRAINING

Although the Isotopes Division is not primarily responsible for establishing or operating training courses in isotope utilization, it does have a fundamental interest in such programs. The greatest single deterrent to wider use of radioisotopes has been the lack of trained persons qualified to handle and conduct research with these materials.

The Isotopes Division has cooperated with the Oak Ridge Institute of Nuclear Studies in setting up the radioisotope-technique courses currently offered by that group. These courses are four weeks in duration and are designed to teach mature research workers to use radioisotopes safely. This training is valuable, but since it is of a general nature, it is recommended that a prospective user of radioisotopes also plan to visit, for an additional month, an institution utilizing them in his field of interest.

VISUAL AIDS

One of the most effective ways of familiarizing technical personnel with the use of isotopes is to [illegible] scientific and technical meetings, exhibits which present the information in illustrative

1185003

and diagrammatic form. The Isotopes Division has prepared several panel exhibits illustrating various fields of application of isotopes and health-safety measures to be employed with radiomaterials. They are available for showing at meetings throughout the country. Also available as visual aids are line-drawing illustrations showing uses of isotopes in several fields of research. In general, these drawings are only loaned and should be returned to the Isotopes Division after use or copying.

Technical assistance is being provided by the Isotopes Division to the Army Institute of Pathology and Signal Corps for the production of a series of technical-level training films on isotope techniques and applications. The first films in this series should be completed during the latter part of 1951. Copies will be made available through the Army Signal Corps film libraries.

ISOTOPICS — ANNOUNCEMENTS OF THE ISOTOPES DIVISION

Isotopics is a bulletin for isotope users which will furnish pertinent information on isotope procurement, new materials, recommendations on safe handling and disposal of radiomaterials, isotope uses, and other items of general interest.

Isotopics replaces the variety of circulars which have been prepared and distributed by the Isotopes Division. It is prepared by the staff of the Isotopes Division and will be published and printed by the Division of Information Services, U. S. Atomic Energy Commission. Isotopics will not accept for publication papers prepared outside AEC facilities. Isotope users are encouraged to publish reports of their investigations in recognized scientific and technical journals.

Supplements to this catalog will be printed separately and reprinted in Isotopics.

View of radioisotope processing area, Oak Ridge National Laboratory.

1185004

6. General Information

PRODUCTION FACILITIES

It is the policy of the Commission to furnish basic irradiations of materials and to process radioisotopes into simple compound forms. Private industry is encouraged to undertake further processing of the isotopes into more complex chemical forms.

Oak Ridge National Laboratory is the major producer and distributor of processed radioisotopes. In February 1950, that facility placed in operation a new processing area which permits large-scale preparation of basic radiomaterials in simple compound forms at considerable saving to the user.

Reactors at Argonne and Brookhaven national laboratories are primarily research instruments, but they are available for special irradiations as described on pages 25 to 28. The national laboratories, the University of California Radiation Laboratory, and Los Alamos Scientific Laboratory have also carried on extensive research and development work in the synthesis of labeled compounds.

PRICING POLICIES

Prices and charges for radiomaterials distributed by the Commission are based on "out-of-pocket" production costs which do not include (1) costs for amortization of the reactor and other major facilities and (2) research and development costs.

Prices are reduced as economies are effected in operations. Several price reductions have been

TRANSPORTATION OF RADIOACTIVE MATERIALS

Any shipment of radioactive materials must be made in conformity with (1) Interstate Commerce Commission Rules and Regulations, (2) Civil Air Regulations, or (3) Postal Laws and Regulations.

NATURALLY OCCURRING RADIOACTIVE MATERIALS

The Isotopes Division authorizes the distribution of reactor-produced radioisotopes; it does not control the distribution of naturally occurring radioactive materials. For information concerning procurement of source materials (uranium and thorium), see Title 11, Chap. I, Part 40, Code of Federal Regulations, or address inquiries to

Licensing Division
New York Operations Office
U. S. Atomic Energy Commission
Post Office Box 30, Ansonia Station
New York 23, N. Y.

RADIATION SOURCES FOR CIVIL-DEFENSE TRAINING

The AEC does not have planning or operating responsibility in the field of civil defense. The Commission's role is primarily to supply to the Federal Civil Defense Administration information on atomic energy which might be useful to the FCDA in discharging its responsibilities for civil defense against atomic warfare. Within the AEC, the Civil Defense Liaison Branch, Division of Biology and Medicine, is responsible for liaison with the FCDA and for coordination of AEC internal-civil-defense activities.

Arrangements have been made, however, for local or state civil-defense agencies to obtain, on loan, radiation sources required for their training programs. An agency requesting such loan will be required to pay only the transportation costs for shipment of sources from Oak Ridge National Laboratory, Oak Ridge, Tenn., and return.

Encapsulated sources will be available in standard activity sizes as follows: 100 mc, 500 mc, and 1 curie. Combinations of these sizes will be provided as needed.

Applications for loan of radiation sources must be prepared on Application for Radioisotope Procurement, Form AEC-313, and submitted to the Isotopes Division, Oak Ridge, Tenn. All applications are subject to approval by the FCDA. In order to coordinate requests for loans from the various local agencies within the states, all such local requests must be cleared through the appropriate state civil-defense director before consideration will be accorded them.

The Isotopes Division will issue Authorization for Radioisotope Procurement, Form AEC-374, on approved application and will forward it directly to the Oak Ridge National Laboratory. The Isotopes Division will assist in scheduling the shipment of radiation sources.

SUGGESTIONS CONCERNING INSTITUTIONAL ISOTOPE COMMITTEES

The Atomic Energy Commission has the Advisory Committee on Isotope Distribution to advise on the establishment of new policies in the distribution program and to review existing policies. On specific problems referred to it by the Isotopes Division, the Committee functions as two Subcommittees

1. The Subcommittee on Human Applications to review applications for radioisotopes to be used in human beings
2. The Subcommittee on General Applications to review all other applications for radioisotopes

1185006

The Advisory Committee recommends that every institution which uses radioisotopes from an isotope committee to supervise and control the use of radioisotopes within the institution. The Commission recommends that the institutional isotope committee follow an organization pattern similar to that of the Advisory Committee.

The Commission requires that an application be approved by a local isotope committee before an authorization will be issued for use of radioisotopes in human subjects (see page 48) and when the institution makes application for a General Authorization for use of radioisotopes in research and development (see page 44). An institution using isotopes in human beings and in general research may form a combined committee to perform both functions stated above or may find it more practical to have two separate committees. The names, organizational titles, and the experience of appointees to the local institutional isotope committee must accompany an application.

Formation of an Isotope Committee on Human Uses

Membership of the local isotope committee in a hospital or medical institution using radioisotopes in medical research or therapy should include

1. A physician trained in internal medicine
2. A physician trained in hematology
3. An individual experienced in assay of radiomaterials and protection of personnel against ionizing radiations
4. Whenever possible, a qualified physicist and a therapeutic radiologist, or they should be available in a consulting capacity.

Formation of an Isotope Committee on General Uses

The background and experience of members of this committee may be widely diverse. Composition of the membership may include

1. A representative of the administrative or business office
2. The radiological safety officer
3. One or more persons with training and experience in the safe use of radioactive materials (radiochemist, radiobiologist, radiophysicist, etc.)
4. Other representatives as seem appropriate to the scope of the program (agronomists, physiologists, zoologists, etc.)

Duties of the Committee

Detailed duties may be described in a letter of appointment. Generally the Committee should have responsibilities to perform the following duties:

1. Review and grant permission for, or disapprove, the use of radioisotopes within the institution from the standpoint of radiological safety
2. Prescribe special conditions as may be necessary (such as physical examinations, additional training, designation of limited area or location of use, disposal methods, etc.)
3. Receive reports from the radiological safety officer and review his records
4. Recommend disciplinary action when an investigator fails to observe safety recommendations, rules, or regulations
5. Keep a record of actions taken in approving the use of radioisotopes and of other transactions, communications, and reports

Please address communications on the allocation, procurement, and use of radioisotopes to

Radioisotopes Branch
Isotopes Division
U. S. Atomic Energy Commission
Oak Ridge, Tenn.

1185007

SUGGESTIONS CONCERNING AN INSTITUTIONAL RADIOLOGICAL SAFETY OFFICER

The radiological safety officer of an institution need not be a member of the institutional isotopes committee described above. However, responsibilities of this position should be assigned to a single individual, although specific duties may be delegated by him to one or several assistants.

If the radioisotopes program at an institution is very broad, that is, including several departments, the duties of the radiological safety officer should be stated in greater detail than described in General Authorizations (page 44). The following are examples of statements that may be made to describe his duties:

1. Make systematic surveys of areas in which the presence of ionizing radiations is suspected; post warning signs in areas found to be contaminated or otherwise the source of hazardous radiation
2. Regularly monitor all incoming and outgoing shipments; check containers for contamination; check for conformity with shipping regulations (ICC, CAB, Post Office Department)
3. Monitor storage and using areas as frequently as necessary; upon completion of experiments, monitor laboratory space involved
4. Supply the necessary or prescribed personnel monitoring devices (film badges, pocket meters, dosimeters, etc.) and give instructions in the proper use of such devices
5. Calibrate and repair survey instruments as frequently as necessary
6. Review for the institutional isotope committee the potential radiological hazards of proposed experiments
7. Calculate the levels of radiation intensity, the time limits of personnel exposure, and the minimum working distance
8. Supervise decontamination procedures
9. Report hazardous radiological conditions promptly to the experimenter responsible for the condition and to the institutional isotope committee
10. Supervise the disposal of radioactive wastes

It is important to stress the need for complete records of the receipt, storage, use, transfer, and disposal of radioisotopes. Any unusual situation should also be fully recorded, for instance, an incident of overexposure and remedial actions taken. The radiological safety officer should be the responsible individual for the maintenance of proper records.

Please address communications on radiation health and safety to

Advisory Field Service Branch
Isotopes Division
U. S. Atomic Energy Commission
Oak Ridge, Tenn.

1185008

7. International Distribution

EXPORT OF REACTOR-PRODUCED RADIOISOTOPES

The export of isotopes is limited to the following radioactive materials:

Antimony 122, 124, 125	Carbon 14	Gold 198, 199	Phosphorus 32	Sodium 24
Argon 37	Chlorine 36	Iodine 131	Platinum 197, 199	Strontium 89, 90
Arsenic 76, 77	Cobalt 60	Iron 55, 59	Potassium 42	Sulfur 35
Bromine 82	Copper 64	Mercury 197	Scandium 46	Tin 113, 121, 123, 125
Calcium 45	Germanium 71, 77	Palladium 103	Silver 110, 111	Zinc 65

The following outline gives the procedure for handling foreign applications. Additional information and application forms may be obtained from the Export-Import Branch, Isotopes Division. All correspondence should be written in English in order to save time and to avoid misinterpretation of technical information.

The technical staff of the Isotopes Division will provide information or references on techniques in the use of radioisotopes.

Outline of Procedure for Handling Foreign Applications

1. Subject to limitations on availability of supplies, radioisotopes will be furnished for uses in scientific research, medical research and therapy.

2. Each foreign government interested in having radioisotope shipments made to eligible users in its country is requested to address a note to the Secretary of State, stating

a. The name of a representative (or agent) in the United States who will handle matters connected with radioisotope shipments (Such representative may be a diplomatic official, a commercial concern, or any other person or corporation selected by the foreign government. The representative should be authorized to maintain liaison with the U. S. Atomic Energy Commission and to complete financial and shipping arrangements, such as payments for materials, deposits for shipping containers, and arrangements for transportation.)

b. That the representative is authorized to certify in behalf of the government to the accuracy of the information set forth in each application for radioisotopes

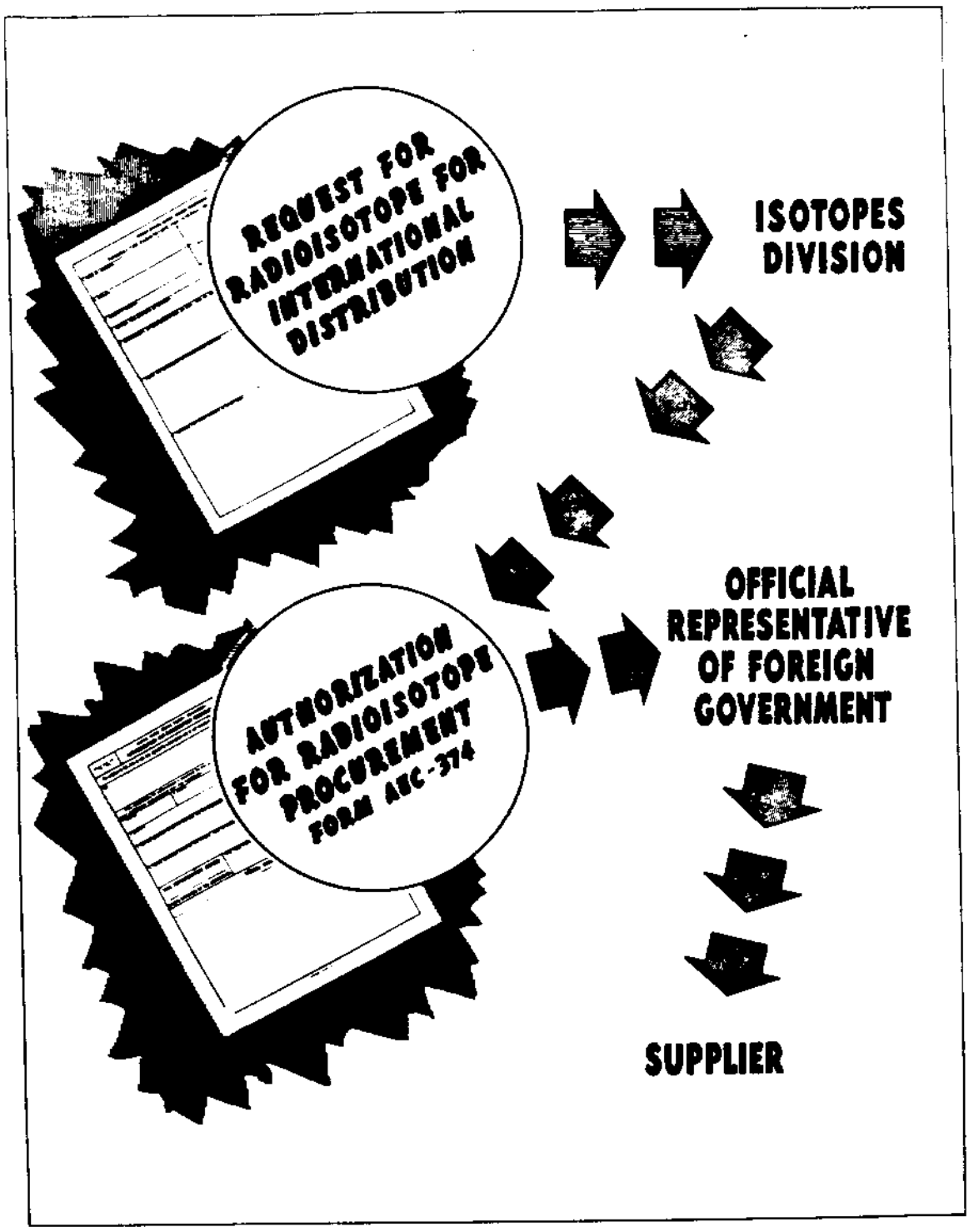
c. That the foreign government understands that there are special health and safety hazards arising out of the possession, handling, or use of radioisotopes, and that such hazards require special protective measures

d. That the foreign government agrees that neither the United States Government nor any United States distributing agent shall be responsible for injury or damage caused by, or in the application of, any radioisotopes delivered

3. Following the deposit of such a note with the Department of State, individual applications for radioisotopes should be submitted to the U. S. Atomic Energy Commission by or through the representative designated by the foreign government pursuant to paragraph 2 above. (A new note need not be presented to the Department of State unless the authorized representative shall have changed, or unless there should be some material change in the information supplied in the original registration.) Applications should be addressed to

Export-Import Branch
Isotopes Division
U. S. Atomic Energy Commission
Post Office Box E
Oak Ridge, Tenn.

1185009


REQUEST FOR RADIOISOTOPE FOR INTERNATIONAL DISTRIBUTION
ISOTOPES DIVISION
AUTHORIZATION FOR RADIOISOTOPE PROCUREMENT FORM AEC-374
OFFICIAL REPRESENTATIVE OF FOREIGN GOVERNMENT
SUPPLIER

1185010

An application may be accompanied by a purchase order made out to the supplier. It is not essential, however, that a purchase order be submitted until the Commission has issued Authorization for Radioisotope Procurement, Form AEC-374. The application should include adequate information on the following:

a. Name and catalog item number of radioisotope desired
b. Quantity desired
c. Desired time and rate of deliveries
d. Names and experience of persons who will use materials furnished
e. Name of institution at which materials will be used
f. Purposes for which materials will be used
g. Health and safety measures to be employed

4. The application should contain the following statement:

The undersigned, in behalf of the government he represents, agrees to the following undertakings:

a. To furnish the U. S. Atomic Energy Commission upon request, or in any event at intervals of not more than one year, results of progress obtained with the use of radioisotopes procured from its facilities

b. That the materials will not be used in a manner other than described in this request

c. To facilitate exchange of information and visits relative to work with radioisotopes between qualified scientists in accordance with normal scientific practice.

5. Applications which the U. S. Atomic Energy Commission may receive directly from institutions or doctors in foreign countries ordinarily will be referred to the representative designated pursuant to paragraph 2 above, for handling and consideration in accordance with established procedures.

6. In view of the special health and safety hazards, it is hoped that each interested foreign government will establish adequate procedures for reviewing the merits of an application prior to its submission to the U. S. Atomic Energy Commission. In this connection, it may be helpful to refer to other sections of this catalog which describe procedures followed in the United States. The adoption of comparable procedures in other countries would assist in maintenance of health and safety standards and bene... utilization of radioisotopes available in the United States for foreign distribution.

7. A fore... application will be reviewed by the Isotopes Division as in the case of a domestic application. When the C... mission determines that the material can be furnished, an Authorization for Radioisotope Procurement, Form AEC-374, will be issued.

8. Shipping arrangements should be mad... with the supplier. Customs clearance and transportation outside the continental limits of the United States should be arranged by the representative designated pursuant to paragraph 2. Shipments from U. S. Commission facilities will be sent to any point within the continental limits of the United States, shipping charges collect.

9. Radioisotopes require a Department of Commerce license as authorization for export. The Department of Commerce will issue to the official representative, appointed pursuant to paragraph 2 above, a blanket license covering all items on the United States isotope-export list for a period of one year. The representative should submit Application for Export License, Form IT-419, to

Office of International Trade
Department of Commerce
Washington, D. C.

IMPORT OF REACTOR-PRODUCED RADIOISOTOPES

Canada

Radioisotopes produced in the nuclear reactor at Chalk River are available for distribution to users in the United States. Details of the procedure for obtaining such materials are as follows:

1. The United States applicant will submit Application for Radioisotope Procurement, Form AEC-313, to the Export-Import Branch, Isotopes Division. Under Item 8 of the application, it should be specified that the material is to be procured from Canada.

1185011

2. The Isotopes Division will review the application in the same manner as for radiomaterials produced in the United States. If the application is approved, an Authorization for Radioisotopes Procurement, Form AEC-374, will be issued to the applicant, together with copies of Canadian application blanks.

3. The applicant will complete, sign, and return the Canadian application blank, together with purchase order and shipping instructions to the Isotopes Division. All purchase orders should be made out to

Eldorado Mining and Refining (1944) Ltd.
Post Office Box 379
Ottawa, Ontario, Canada

4. The Isotopes Division will forward the application, purchase order, shipping instructions, and certifying statement required by Canadian National Research Council to the official United States representative for radioisotope procurement in Canada, who will submit them to the Isotopes Branch, Atomic Energy Control Board, National Research Council, Chalk River, Ontario.

5. If approval is granted by Canada, the supplier (Eldorado) will make shipment direct to the applicant in accordance with instructions previously furnished by the United States representative. Invoices will be submitted by the supplier to the recipient after shipment has been made.

The above procedure may be condensed by the submission of Form AEC-313, Canadian application blanks, purchase order, and shipping instructions at the same time. If no alteration in the Canadian application is necessary, the Isotopes Division will forward it directly to the United States representative in Canada.

Copies of the Canadian catalog may be obtained from

Isotopes Branch
Atomic Energy Control Board
National Research Council
Chalk River, Ontario, Canada

United Kingdom

Radioisotopes produced in the nuclear reactor at Harwell are available for distribution to users in the United States. Details of the procedure for obtaining these materials are as follows:

1. The United States applicant will submit Application for Radioisotope Procurement, Form AEC-313, to the Export-Import Branch, Isotopes Division. Under Item 8 of the application, it should be specified that the material is to be procured from the United Kingdom.

2. The Isotopes Division will review the application in the same manner as for radiomaterials produced in the United States. If the application is approved, an Authorization for Radioisotope Procurement, Form AEC-374, will be issued to the applicant. In the case of general authorizations issued for research purposes, the recipient may also obtain isotopes from the United Kingdom under this authorization without submission of an additional application.

3. The applicant will submit a request form for the desired radioisotope to (a) Isotope Division, Atomic Energy Research Establishment, Harwell, Berks., England [for items marked (H) in the British catalog] or (b) Radiochemical Centre, Amersham, England [for items marked (A) in the British catalog].

4. All arrangements for shipment and payment will be made directly between the United States applicant and proper British groups.

Copies of British catalogs and request forms may be obtained from

Isotope Division
Atomic Energy Research Establishment
Harwell, Berks., England

1185012

8. Code of Federal Regulations: Radioisotope Distribution

Title 10 — ATOMIC ENERGY

United States Atomic Energy Commission

Part 30 — Radioisotope Distribution*

GENERAL PROVISIONS

30.1 Scope. The regulations in this part establish instructions and standards governing the procurement, delivery, possession, use, transfer (including export), and disposal of radioisotopes (a) originating in or procured from the facilities of the Commission or of a distributor, or (b) originating in domestic facilities not owned by the Commission but distributed by or through the Commission

*Sections 30.1 to 30.71, ~~Mar. 15, 1~~ 1, April 1[illegible]

1185013

or a distributor, or (c) originating in any foreign nuclear reactor for shipment into the United States. The regulations in this part do not apply to source and fissionable materials as defined herein or to any radioactive material not covered by the immediately preceding sentence.

30.2 Definitions. As used in this part: (a) "Commission" means the United States Atomic Energy Commission created by the Atomic Energy Act of 1946, or its duly authorized representative.

(b) "Distributor" means any person to the extent that such person is engaged in operating Commission-owned laboratories, plants, or other facilities under a contract with the Commission and is engaged in the distribution of radioisotopes for the Commission.

(c) "Fissionable material" means fissionable material as defined in Section 5(a)(1) of the Atomic Energy Act of 1946 and in the regulations contained in Part 70: Definition of Fissionable Material.

(d) "One millicurie" means that amount of radioactive material which disintegrates at the rate of 37 million atoms per second.

(e) "Person" means any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, the United States or any agency thereof, any government other than the United States, any political subdivision of any such government, and any legal successor, representative, agent, or agency of the foregoing, or other entity, but shall not include the Commission or officers or employees of the Commission in the exercise of duly authorized functions.

(f) "Radioisotope" means any radioactive material yielded in or made radioactive by exposure to the radiation incident to the processes of producing or utilizing fissionable material. Radioisotope also means any other radioactive material.

(g) "Roentgen" (= r) means that quantity of X or gamma radiation such that the associated corpuscular emission per 0.001293 gram of air produces, in air, ions carrying 1 electrostatic unit of electricity of either sign.

(h) "Roentgen-equivalent-man" (= rem) means that quantity of radiation that, when absorbed by mammalian tissue, produces an effect equivalent to the absorption by this tissue of one roentgen of X or gamma radiation.

(i) "Roentgen-equivalent-physical" (= rep) means that dose of ionizing radiation that is capable of producing energy absorption of 93 ergs per gram of tissue.

(j) "Service irradiation" means the exposure of materials of any kind to radiation in accordance with instructions and at the request of some person.

(k) "Source material" means source material as defined in Section 5(b)(1) of the Atomic Energy Act of 1946 and in the regulations contained in Part 40: Control of Source Material.

30.3 Amendment. Nothing in this part shall limit the authority of the Commission to issue or amend its regulations in accordance with law.

30.4 Communications. All communications about the regulations in this part or any Authorization issued under them should be addressed to the United States Atomic Energy Commission, Post Office Box E, Oak Ridge, Tennessee, Attention: Isotopes Division.

EXEMPTIONS

30.10 Persons Operating Commission-owned Facilities. The regulations in this part do not apply to persons to the extent that such persons operate Commission-owned facilities in carrying out programs on behalf of the Commission. In such cases the acquisition, transfer, use, and disposal of radioisotopes are governed by the contracts between such persons and the Commission and internal bulletins, instructions, and directives issued by the Commission.

30.11 Transfer to the Commission. The actions of any person in transferring or delivering radioisotopes to the Commission are not subject to the regulations in this part. The exemption provided in this section does not, however, relieve any person from the obligation to comply with shipping requirements otherwise provided by law (see Section 30.41).

30.12 Carriers. Common and contract carriers transporting radioisotopes in the normal course of business are exempt from the regulations in this part.

1185014

30.13 Items and Quantities. (a) Sections 30.20 through 30.61, inclusive, do not apply to any item listed in Section 30.70 (Schedule A) nor to any quantity listed in Section 30.71 (Schedule B) provided, however, that no person shall, except as otherwise permitted by the regulations contained in this Part, effect an increase in the radioactivity of such scheduled items or quantities by adding other radioactive material thereto, by combining the radioisotopes from two or more such items or quantities, or by altering them in any other manner so as to increase thereby the rate of radiation exposure of himself or others above the original rate therefrom.

(b) In addition the Commission may, upon application of any interested party, exempt specific items from the application of all or any portion of the regulations in this part subject to such conditions as the Commission may establish whenever the Commission determines that the possession, use, or transfer, or such items will not endanger health or present a hazard to life or property.

APPLICATIONS

30.20 Filing. (a) Any person, except the official representative of a foreign applicant, who desires to possess or use radioisotopes shall file Application for Radioisotope Procurement, Form AEC-313, with the Isotopes Division of the Commission, or such other place as may be designated by the Commission, specifying the use to be made of the material and giving all other information called for by the form. Copies of the form will be furnished upon request to the United States Atomic Energy Commission, Post Office Box E, Oak Ridge, Tennessee, Attention: Isotopes Division.

(b) Applications for radioisotopes to be used in a foreign country shall be submitted through that country's official representative in charge of isotope procurement. Upon request, foreign representatives will be informed by the Commission of the desired form and content of applications and the terms and conditions upon which radioisotopes may be obtained.

30.21 Conditions. The Commission will not approve a domestic Application (a) unless the radioisotope is requested for one or more of the following purposes: research or development activity, medical therapy, industrial uses, processing or making of compounds, or such other useful applications as may be developed; or (b) if it is determined by the Commission that the applicant is not equipped to observe the health and safety standards established by the Commission; or (c) if it is determined by the Commission that the applicant is not qualified to use radioisotopes for the requested purpose.

30.22 Service Irradiations. Upon receipt of an Application requesting that radioisotopes be produced through a service irradiation, the Commission may authorize such irradiation and subsequent possession and use of the irradiated materials in accordance with the regulations contained in this part.

AUTHORIZATIONS

30.30 Issuance. Upon approval of an Application, the Commission will issue an Authorization for Radioisotope Procurement, Form AEC-374. The Authorization shall be the only valid approval for procurement, and its issuance shall be based upon the representations in the Application and shall be subject to and in accordance with the regulations in this part and the terms and conditions stated in the Application.

30.31 Nontransferability. The person to whom an Authorization has been issued shall be deemed the holder thereof, and none of the rights or privileges conferred by the Authorization shall be transferable.

30.32 Expiration. An Authorization shall be valid only for the period stated thereon; it shall expire at the end of such period without the necessity of notice or warning from the Commission. The holder shall not order radioisotopes after the period of validity stated on the Authorization has run.

30.33 Modification. Upon written request from the holder of an Authorization for a modification of its terms, the Commission will usually consider the request without requiring a separate application, and it may modify the Authorization by giving written notice to the holder or by issuing a supplemental Authorization.

1185015

30.34 Revocation. Any Authorization may be annulled, suspended, or revoked at any time in the discretion of the Commission upon a determination by the Commission that the public health or safety requires such action, or that the holder has willfully failed to comply with any term or condition to which his Authorization may be subject. In the absence of such determination, no annulment, suspension, or revocation of any Authorization will be made except upon request of the holder thereof, or unless conduct or other facts meriting such action shall have been called to the attention of the holder previously in writing, and unless he shall have been accorded opportunity to comply with all lawful requirements but shall have failed to do so.

POSSESSION, TRANSFER, USE

30.40 Limitations. No person shall possess, use, or transfer radioisotopes except as permitted by a valid Authorization from the Commission or as otherwise permitted by the regulations in this part. When transferring any nonexempt items or quantities of radioisotopes, the transferor shall limit delivery to the locations, materials, and quantities stated in the transferee's Authorization.

30.41 Authorized Use. Each person authorized by the Commission to use radioisotopes shall confine his use to the locations and purposes approved by the Commission on his Authorization, and such use is subject to all applicable laws, regulations of the Commission, and terms and conditions stated in the application for such material.

NOTE: Shipment and use of radioisotopes may also be subject to control by other authority; see, for example, (a) Federal Food, Drug, and Cosmetic Act and the general regulations for its enforcement, (b) Rules and Regulations of the Interstate Commerce Commission, (c) Civil Air Regulations, (d) Postal Laws and Regulations, and (e) Laws and Regulations of State or other local authority.

RECORDS, REPORTS, INSPECTIONS

30.50 General Records. Each person who possesses or uses radioisotopes shall keep permanent records showing the receipt, use, storage, delivery, and disposal of such radioisotopes and the safety measures used to protect health. These records shall be accurate and complete and shall be made available to the Commission upon request.

30.51 Overexposure Records. No report of the overexposure of a person to radioisotopes need be forwarded to the Commission, but where an overexposure is believed to have occurred, the occurrence and its observed effect upon the overexposed person shall be recorded in detail and filed with the general records.

30.52 Reports of Use. Upon written request from the Commission, any person who uses radioisotopes shall report fully the use made, stating substantially those facts required by Sections 30.50 and 30.51 to be recorded.

30.53 Reports of Transfer. In the absence of written waiver by the Commission, any person who transfers radioisotopes to another person shall promptly report to the Commission each delivery made, indicating the name and location of the transferee, transferee's Authorization number, type and amount of material transferred, and date of delivery.

30.54 Inspections. Each person who possesses or uses radioisotopes shall permit the Commission, at all reasonable times, to make such inspections of the facilities wherein materials are stored or used as the Commission deems necessary and shall make available to the Commission the records required by Sections 30.50 and 30.51.

VIOLATIONS

30.60 Right to Recall. The Commission may withhold or recall radioisotopes from any person when it is determined by the Commission that such person (a) is not equipped to observe the health and safety standards established by the Commission or has failed to do so; (b) has used the material

in a manner other than as disclosed in the application therefor; or (c) has used the material in violation of any law or of any regulation of the Commission.

30.61 Other Action. Any person who violates any provision of these regulations, or who, in connection with these regulations, willfully conceals a material fact or furnishes false information to the Commission, may be prohibited by the Commission from making or obtaining further deliveries of radioisotopes or using, possessing, or storing them and may be required to return to the Commission all radioisotopes remaining on hand. Violation of the regulations contained in this part or the furnishing of false information in connection with applications, statements, and reports thereunder may also be a crime under the provision of the Atomic Energy Act of 1946 or of 18 USC §1001, Act of June 25, 1948, 62 Stat. 749.

SCHEDULES

30.70 Schedule A: Exempt items. (See Section 30.13.) None.

30.71 Schedule B: Exempt quantities. (See Section 30.13.)

(a) Alpha Emitters: None.

(b) Beta and Gamma Emitters: Not more than a combined total of 0.011 millicurie, made up as follows: (a) Half-lives no greater than 30 days: Not more than 0.010 millicurie. (2) Half-lives greater than 30 days: Not more than 0.001 millicurie.

(c) Neutron Emitters: None.

NOTE: The quantities listed in Schedule B are not to be interpreted or considered as having any bearing on the determination of safe permissible levels of personal exposure or for waste disposal. It is the Commission's intention to publish at a later date and incorporate in this part appropriate health and safety standards.

1185017

Bibliography and List of References

REPORTS AND CIRCULARS

General

Glasstone, S., editor, Effects of Atomic Weapons, Superintendent of Documents, Government Printing Office, Washington, D. C.

Isotopes ... A Three-Year Summary of U. S. Distribution, U. S. Atomic Energy Commission Report, Superintendent of Documents, Government Printing Office, Washington, D. C.

Nuclear Data, National Bureau of Standards Circular 499, Washington, D. C.

Nuclear Science Abstracts, U. S. Atomic Energy Commission Report, Office of Technical Services, Department of Commerce, Washington, D. C.

Radiation Instruments Catalog, Office of Technical Services, Department of Commerce, Washington, D. C.

U. S. Atomic Energy Commission Semiannual Reports, Superintendent of Documents, Government Printing Office, Washington, D. C.

Fourth Report, Recent Scientific and Technical Developments in the Atomic Energy Program
Fifth Report, Atomic Energy Development
Sixth Report, Atomic Energy and the Life Sciences
Seventh Report, Atomic Energy and the Physical Sciences
Eighth Report, Control of Radiation Hazards in the Atomic Energy Program

Health and Safety

ABC's of Radiation, Brookhaven National Laboratory Report, Associated Universities, Inc., Upton, L. I., N. Y., 1949.

Interim Recommendations for the Disposal of Radioactive Wastes by Off-Commission Users, Isotopes Division Circular B-6.

Morgan, G. W., Surveying and Monitoring of Radiation from Radioisotopes, Nucleonics, 4: No. 3 (1949) (available from Isotopes Division).

Safe Handling of Radioisotopes, National Bureau of Standards Handbook 42, September 1949 (available from Isotopes Division).

Some Practical Considerations in Radiation Shielding, Isotopes Division Circular B-4, November 1948.

The Design of Laboratories for the Safe Handling of Radioisotopes, Isotopes Division Circular B-5.

Medical Applications

References on Therapeutic and Tracer Uses of Radioisotopes, Isotopes Division Circular D-5.

Symposium on Radioactive Isotopes, J. Clin. Invest., 28: No. 6, Part 1 (November 1949).

Labeled Compounds

Crompton, C. E., and Woodruff, N. H., Chemical Syntheses of Labeled Compounds, I and II, Nucleonics, 7: Nos. 3 and 4 (1950) (available from Isotopes Division).

Woodruff, N. H., and Fowler, E. E., Biological Syntheses of Radioisotope-labeled Compounds, Nucleonics, 7: No. 2 (1950) (available from Isotopes Division).

Woodruff, N. H., and Fowler, E. E., Status of Biological Syntheses of Radioisotope-labeled Compounds, Journal of the Tennessee Academy of Science, 24: No. 4 (October 1949).

1185018

BOOKS

Behrens, C. F., editor, "Atomic Medicine," Thomas Nelson & Sons, New York, 1949.

Calvin, M., Heidelberger, C., Reid, J. C., Tolbert, B. M., and Yankwich, P., "Isotopic Carbon," John Wiley & Sons, Inc., New York, 1949.

Glasstone, S., "Sourcebook on Atomic Energy," D. Van Nostrand Company, Inc., New York, 1950.

Hahn, P. F., editor, "Manual of Artificial Radioisotope Therapy," Academic Press, Inc., New York, 1950.

Hevesy, G., "Radioactive Indicators," Interscience Publishers, Inc., New York, 1948.

Lapp, R. E., and Andrews, H. L., "Nuclear Radiation Physics," Prentice-Hall, Inc., New York, 1948.

Lawrence, J. H., and Hamilton, J. G., editors, "Advances in Biological and Medical Physics," Academic Press, Inc., New York, 1948.

Low-Beer, B. V. A., "The Clinical Use of Radioactive Isotopes," Charles C. Thomas, Publisher, Springfield, Ill., 1950.

Shamos, N. H., and Roth, S. G., editors, "Industrial and Safety Problems of Nuclear Technology," Harper & Brothers, New York, 1950.

Siri, W. E., "Isotopic Tracers and Nuclear Radiations," McGraw-Hill Book Company, Inc., New York, 1949.

Smyth, H. D., "Atomic Energy for Military Purposes," Princeton University Press, Princeton, N. J., 1945.

Yagoda, H., "Radioactive Measurements with Nuclear Emulsions," John Wiley & Sons, Inc., New York, 1949.

1185019

Address Guide

Isotopes Division
U. S. Atomic Energy Commission
Post Office Box E
Oak Ridge, Tenn.

Radioisotopes Branch reviews applications and issues authorizations for the domestic procurement of radioactive isotopes, isotope-labeled compounds, and irradiation services.

Stable Isotopes Branch reviews applications and issues authorizations for procurement of stable isotopes and isotope-labeled compounds.

Export-Import Branch reviews applications from foreign countries and issues authorizations for the procurement of radioactive isotopes and isotope-labeled compounds and reviews applications and issues authorizations for the procurement of isotopes reactor-produced in foreign countries.

Advisory Field Service Branch provides advisory field service to assist off-Commission applicants in health protection, radiation monitoring, disposal, and safe practices in the use of radioactive materials.

Technical Reports Branch provides information on production, distribution, and utilization of radioactive and stable isotopes and prepares visual aids for training users in isotope techniques.

Argonne National Laboratory
Post Office Box 5207
Chicago 80, Ill.
Attention: Special Materials Department

Brookhaven National Laboratory
Associated Universities, Inc.
Upton, Long Island, N. Y.
Attention: Isotopes and Special Materials Group

Civilian Defense Administrator
815 Connecticut Ave.
Washington, D. C.

Civil Defense Liaison Branch
Division of Biology and Medicine
U. S. Atomic Energy Commission
1901 Constitution Ave., N. W.
Washington 25, D. C.

Licensing Division
New York Operations Office
U. S. Atomic Energy Commission
Post Office Box 30
Ansonia Station
New York 23, N. Y.

National Bureau of Standards
U. S. Department of Commerce
Van Ness Street and Connecticut Avenue
Washington 25, D. C.
Attention: Radioactivity Section

Oak Ridge National Laboratory, X-10 Plant
Carbide and Carbon Chemicals Division
Union Carbide and Carbon Corporation
Post Office Box P
Oak Ridge, Tenn.
Attention: Isotopes Control Department

Oak Ridge National Laboratory, Y-12 Plant
Carbide and Carbon Chemicals Division
Union Carbide and Carbon Corporation
Post Office Box P
Oak Ridge, Tenn.
Attention: Isotope Research and Production Division
(For electromagnetically separated stable isotopes only)

Office of International Trade
U. S. Department of Commerce
Washington 25, D. C.
Attention: Finished Products Control Division

1185020

Office of Technical Services
U. S. Department of Commerce
Washington 25, D. C.

Radiation Instruments Branch
Division of Biology and Medicine
U. S. Atomic Energy Commission
1901 Constitution Ave., N. W.
Washington 25, D. C.

Stuart Oxygen Co.
351 California St.
San Francisco 4, Calif.
Attention: Heavy Water Department

Superintendent of Documents
Government Printing Office
Washington 25, D. C.

1185021