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RADIOISOTOPE PROGRAM (8000) PROGRESS REPORT FOR NOVEMBER 1972

A. F. Rupp

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Contract No. W-7405-eng-26

ISOTOPES DEVELOPMENT CENTER

RADIOISOTOPE PROGRAM (8000) PROGRESS REPORT FOR NOVEMBER 1972

A. F. Rupp

Work Sponsored by
AEC Division of Applied Technology

DECEMBER 1972

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CONTENTS

Page

RADIOISOTOPE PRODUCTION AND MATERIALS DEVELOPMENT 1

REACTOR-PRODUCED ISOTOPES 1

Silicon-32 1
Gadolinium-153 1
Phosphorus-33 3

ACCELERATOR-PRODUCED ISOTOPES 3

Potassium-43 3
Lead-203 5
Cyclotron Products Pilot Production 6

FISSION PRODUCTS 6

Krypton-85 6
Cesium-137 Pilot Production 7
Strontium-90 Pilot Production 8
Short-Lived Fission Products Pilot Production 9
Promethium-147 Shipments and Current Orders 9

SOURCE DEVELOPMENT 10

Americium-241 10
Radioisotope Characterization, Quality Control, and Standards 10

RADIOISOTOPE SALES 11

ITEMS OF INTEREST 11

ADMINISTRATIVE 13

PUBLICATIONS 14

REPORTS 14

RADIOISOTOPE PROGRAM (8000) PROGRESS REPORT FOR NOVEMBER 1972

A. F. Rupp

RADIOISOTOPE PRODUCTION AND MATERIALS DEVELOPMENT

REACTOR-PRODUCED ISOTOPES — 08-01-01

Silicon-32 *(T. A. Butler)*

Silicon-32 (~650 year) exhibits many desirable physical decay characteristics that make it an interesting and attractive radionuclide for a variety of uses: (1) the only long-lived radionuclide of silicon for use in agriculture, geology, solid-state physics, etc., (2) as a parent for a ^{32}Si-^{32}P *generator system which would offer a constant supply of phosphorus-32 for medical and scientific application, and (3) as a long-lived Cerenkov counting standard for phosphorus-32 determinations. Reactor production of silicon-32, which will be investigated initially, can occur via three completely different reaction paths: (1)* $^{30}Si(n,\gamma)^{31}Si(n,\gamma)^{32}Si$, *(2)* $^{31}P(n,\gamma)^{32}P(n,p)^{32}Si$, *and (3)* $^{34}S(n,\gamma)^{35}S(n,\alpha)^{32}Si$. *Silicon-32 can also be prepared in large quantities via the spallation reaction using high-energy (>100 MeV) protons and will be investigated in collaborative efforts with other AEC laboratories as high currents of these high-energy protons become available.*

Work continues at the tracer level to determine the cause of the observed 5-10% loss of carrier-free silicon-31 during the cation exchange removal of metal ions characteristic of mock $AlPO_4$ targets.[1] These losses are not observed with target materials which do not contain aluminum, e.g., $(NH_4)_2HPO_4$ and K_2SO_4, and they are thought to be due to some type of adsorption effect between the aluminum on the ion exchange resin, and the $^{31}SiO_3^{2-}$ in the mobile phase. Additional experiments will be performed to develop a method of reducing these losses before starting the processing of the long cooled, 3-cycle irradiated $AlPO_4$ on hand.

Gadolinium-153 *(T. A. Butler, F. N. Case)*

Gadolinium-153 (242 days) offers potential as a useful and important radionuclide due to its favorable physical decay characteristics, e.g., it decays solely by electron capture to stable europium-153 with 97- and 103-keV gamma rays and europium x-rays as the predominant accompanying photon emissions. This energy range

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[1] A. F. Rupp, *Radioisotope Program (8000) Progress Report for September 1972*, ORNL-TM-4002, Oak Ridge National Laboratory, p. 2.

is useful for various types of gaging and transmission bone-scanning applications. The neutron burned-out europium control plates from HFIR offer a by-product source of highly enriched gadolinium-152 that would be prohibitively expensive to match by calutron separations.

1. Recovery of Gadolinium-152 from HFIR Control Rods

Recovery of gadolinium-152 from HFIR control plates continued through November. The solvent extraction process was demonstrated on a full-scale run and removal of >90% of the europium from gadolinium was achieved. A second stage separation is in progress, using smaller volume equipment in an attempt to remove >90% of the remaining europium, in order that a suitable target for neutron irradiation of the gadolinium-152 can be made. High-pressure ion-exchange will be used for removal of terbium and europium from the gadolinium-153 product.

2. Purification of Gadolinium-153

Tracer level work continues on a high-pressure ion-exchange separation procedure to purify the gadolinium-153 after the gadolinium-152 has been irradiated to produce the maximum amount of gadolinium-153.[2] The specific activity at this point is expected to be ∿70 Ci of gadolinium-153 per gram of gadolinium. This process must be capable of handling up to gram quantities of gadolinium containing up to 10% terbium and europium. A separation scheme has been developed using a 0.47-in.-ID by 20-in.-long column filled with 20-30 micron Bio-Rad AG50W-X8 cation-exchange resin. Operating at ∿1000 psi and 85°C temperature, 100-mg batches of mixed Tb-Gd-Eu can be fractionated in less than 4 hr. A purified gadolinium fraction was recovered from a synthetic as-irradiated gadolinium-153 product with a gadolinium yield of ≥98% and ≤0.01% terbium and europium cross-contamination. Experimental apparatus for in-cell use has been designed, and fabrication will begin soon. Additional development work will be performed on an in-cell, on-line column effluent monitor to facilitate in-cell column operations. If the 100-mg, in-cell column works well, the apparatus will be scaled-up to handle 400-500 mg batches.

3. Cooperative Work

A number of experimenters have been contacted, and cooperative programs have been set up for use of gadolinium-153 in medical applications. Uses for this isotope include the determination of certain heavy elements in the lung and joints by x-ray fluorescence techniques. Since there are no direct methods available to make these determinations, indirect measurements such as the analysis of body fluids must be used and the contribution of gadolinium-153 x-ray fluorescence analysis to solving this

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[2]A. F. Rupp, *Radioisotopes Program (8000) Progress Report for October 1972*, ORNL-TM-4043, Oak Ridge National Laboratory, p. 4.

medical problem may become significant. The medical applications work will be done at the University of California Medical Center, San Francisco.

Phosphorus-33 *(T. A. Butler)*

The 1.06-g $K^{36}Cl$ target processed last month was recovered, purified, and reencapsulated. The recovery of $K^{36}Cl$ was >99%. The isotopic analysis was: 6% ^{35}Cl, 68% ^{36}Cl, and 26% ^{37}Cl. A spark source analysis showed the main impurity as calcium, with 1.8% molybdenum, and 0.3% sulfur.

Another $K^{36}Cl$ target which had been contaminated with nitrate was recovered by precipitating $Ag^{36}Cl$, dissolving this in ammonia, and then precipitating Ag_2S with H_2S. The 1.02 g recovered represents approximately 90% of the original target. The isotopic analysis was: 6% ^{35}Cl, 64% ^{36}Cl, and 30% ^{37}Cl. Spark source analysis showed the major contaminant to be calcium, with 0.8% sodium and 0.6% sulfur.

A regular target and 2.29 g of $K^{36}Cl$ (52% enrichment) were enriched concurrently by HFIR irradiation. Since it is necessary to reencapsulate this for further irradiation, it was processed by a revised, simplified procedure for phosphorus-33 recovery. The target was dissolved and passed through a H^+ cation column. The iron carrier was introduced by dissolving freshly precipitated $Fe(OH)_3$ in the $H^{36}Cl$-$H_3{}^{33}PO_4$ solution. Precipitation of $Fe(OH)_3$ was accomplished using cesium-free KOH and adjusting the pH to 9 with paper indicator. This procedure avoids addition of SO_4^{2-} and obviates the need for the $BaSO_4$ precipitation. Although the phosphorus-32 content is high, the phosphorus-33 obtained was combined with another batch having high phosphorus-32 content, and when this reaches the 5% phosphorus-32 specification 90 mCi will remain. The $K^{36}Cl$ was totally recovered, and a sample was taken for isotopic analysis before it was reencapsulated in quartz. Elimination of phenolphthalein as an indicator in the KOH titration resulted in recovery of a pure white $K^{36}Cl$ target after it was heated at 450°C, without resorting to the usual use of decolorizing charcoal to remove the decomposition products of the indicator.

A $K_2{}^{33}SO_4$ target has been removed from the reactor and will be processed to fill orders for 200 mCi.

ACCELERATOR PRODUCED ISOTOPES — 08-01-02

Potassium-43 *(T. A. Butler)*

Potassium-43 (22.5 hr) has been shown through medical cooperative programs between the ORNL Isotopes Division and a number of medical investigators throughout the country to be an excellent tool for studying blood flow through the heart and for diagnosing myocardial infarctions. Since cardiovascular disease is still the number one killer in the country, the contribution of methods utilizing potassium-43 to the diagnosis, treatment, and management of this group of diseases would be truly worthwhile. Potassium-43 has been and is currently

being produced in the HFIR by the $^{43}Ca(n,p)^{43}K$ reaction using highly enriched ^{43}CaO targets; sufficient quantities, e.g., approximately 20 mCi per batch, have been made for initial medical and biological evaluation studies. Potassium-43, with its 22.5-hr half-life and 373- and 617-keV gamma-ray emissions in high abundances, is more suitable than potassium-42 for *in-vivo* metabolic and clinical studies in human subjects.

We are proposing a preliminary experiment to be performed at the Oak Ridge Electron Linear Accelerator (ORELA) to determine whether sufficient quantities of potassium-43 can be prepared via the $^{44}Ca(\gamma,p)^{43}K$ photonuclear reaction to warrant further effort to develop this path for large-scale production. In order to have appreciable impact upon patient care, curie quantities would have to be produced for approximately $10 to $25 per millicurie, compared to the current price of $100 per millicurie.

Barbier estimates in Appendix D of his book ("Gamma Activity Induced by Giant Resonance Reactions")[3] a thick-target production rate for potassium-43 from a natural calcium target of 2×10^{-6} dis/sec.MeV primary electron energy, for an electron current of 1 electron/sec. Assuming ORELA could furnish approximately 0.34 mA of 140-MeV electrons at the 50-kW power level of operation, the end of bombardment, "saturation" activity of potassium-43 for an infinitely thick calcium target would be approximately 16 Ci. Preliminary discussions with ORELA scientists familiar with photonuclear reaction systematics lead to the conclusion that Barbier's estimates are probably good within a factor of 2 to 4, and almost surely within a factor of 10. Due to both the low Z and low density of calcium and its compounds, the engineering problems of achieving a sufficiently "thick" target to absorb the maximal number of high-energy photons [i.e., gammas with energies greater than the $^{44}Ca(\gamma,p)^{43}K$ threshold of 12.17 MeV] would seem to be one of the more important limiting factors for any possible experiment. Before becoming involved in theoretical and engineering studies, it is proposed that a preliminary, low-level (approximately 0.1-0.2% of maximum beam intensity) experiment be performed under significant, but not necessarily optimal, conditions to determine if the above mentioned estimates are reasonable and whether further work seems warranted.

The preliminary experiment will use CaO as the target material. This compound has a number of good characteristics: (1) melting point = 2580°C; (2) calcium atom density highest of all materials considered, including calcium metal; and (3) ready availability at relatively low cost. The major disadvantage of using this compound is that it is very difficult to compact to its maximum density. The radiation length of CaO was calculated to be 19.4 g/cm^2 using equations 5.2.1 and 2.11.18 of Rossi.[4] Based on a theoretical density of 3.3 g/cm^3 for CaO, this

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[3] M. Barbier, *Induced Radioactivity*, Wiley, New York, 1969, p. 355.

[4] B. B. Rossi, *High Energy Particles*, Prentice-Hall, New York, 1952, pp. 53, 220.

radiation length is 5.9 cm (2.3 in.). Preliminary experiments to determine the bulk density of CaO have indicated that powdered CaO can be vibrated and hand-tamped to only approximately 38% of theoretical density, so the effective radiation length for this target would be approximately 6 in.

Since the effective radiation length is so large, a relatively massive target must be considered in order to absorb a significant fraction of the high-energy photons. In order to minimize costs, a 55-gal stainless steel drum (23-in. cross section by 35-in. height by 0.060-in. wall thickness) is presently under consideration for the target holder. This would correspond to approximately 2 radiation lengths radius by approximately 6 radiation lengths along the beam axis. It is estimated that approximately 660 lb of CaO, at 38% of theoretical density, will be required to fill this container. At 0.1-0.2% of maximum beam power, the energy dissipation in the target should be $\leq$ 100 W, which should require no additional cooling. These drums, which are used for radioactive waste burial, can be sealed well to minimize problems of loose contamination.

It is hoped that the target can be irradiated parasitically at a pulse rate of 1 or 2 pulses per sec for a 24-hr duration at the 20° port position of the beam-monitoring switching magnet at ORELA. The following maximum yields for various radioactivities induced in 660 lb of CaO have been estimated from the data of Barbier for a 24-hr run at 2 pulses per sec: ^{43}K (22.5 hr), ∿17 mCi; ^{42}K (12.42 hr), ∿1.5 mCi; ^{38}K (7.68 m), ∿110 mCi.

Lead-203 *(T. A. Butler)*

> *Lead-203 (52.1 hr) has been suggested as a possible bone-scanning agent, chelated as a cisternographic agent, and possibly as a tumor-localizing agent. The radioisotope has an acceptable half-life for production and shipment and low radiation dose decay characteristics (i.e., it decays solely by electron capture with the emission of two main gamma rays of 279 and 401 keV with intensities of 81 and 5%, respectively). Three medical cooperative programs have been established to perform the varied applications evaluation of this nuclide.*

Preliminary experiments utilizing the ^{203}Tl(p,n)^{203}Pb reaction path continued. A 3-in.-void-length vented aluminum capsule containing 5.7 g natural Tl_2O_3 was irradiated in the ORNL 86-Inch Cyclotron and then utilized for process development. The basic chemical process, which was similar to that employed in an earlier experiment,[5] involved dissolution of the entire aluminum capsule in HBr, isopropyl ether

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[5]A. F. Rupp, *Radioisotope Program (8000) Progress Report for May 1971*, ORNL-TM-3461, Oak Ridge National Laboratory, p. 5.

extraction of the macro amounts of Tl(III) target material, followed by anion-exchange chromatography from HBr solution utilizing the work of Andersen and Knutsen[6] to separate the carrier-free ^{203}Pb(II) from any traces of thallium and the macro amounts of aluminum from the initial dissolution. Even though some difficulties were encountered during target dissolution, the procedure appears more suitable for high-level cell operation than the $Fe(OH)_3$ coprecipitation scheme used earlier.[7] A potassium iodide chemical spot test[8] was used for thallium quality control and indicated <20 ppm thallium in the product. A portion of the purified product was shipped to one cooperating participant for evaluation, while the remainder was retained for additional product characterization and development work on the hydrous zirconium oxide inorganic anion-exchange separation of Tl(I) and Pb(II) mentioned earlier.[7]

Cyclotron Products Pilot Production (Production and Inventory Accounts) *(L. O. Love)*

November 1972 ORNL 86-Inch Cyclotron runs for ORNL and non-ORNL programs are given in Table 1.

Table 1. Cyclotron Irradiations and Runs for November 1972

Product	No. of Runs	Time (hr:min)	Total Charges
		ORNL Programs	
Cobalt-57	1	39:15	$3886
Gallium-67	2	18:10	1740
		57:25	$5626
		Non-ORNL Programs	
Bismuth-207	1	9:15	Stock

FISSION PRODUCTS — 08-01-03

Krypton-85 Enrichment *(R. A. Robinson)*

All enriched product material has been removed from the thermal diffusion units and is stored in shielded cylinders for sales inventory. The

[6]T. Andersen and A. B. Knutsen, *A. Chem. Scand.* 16, 849 (1962).

[7]A. F. Rupp, ORNL-TM-4002, p. 4.

[8]F. Feigel, *Spot Tests in Inorganic Analysis*, Elsevier, New York, 1958, p. 154.

remaining low-level material is being recovered from the units and transferred to the in-cell storage cylinders.

Cesium-137 Pilot Production (Production and Inventory Accounts) *(R. W. Schaich)*

1. Process Status

One cesium carbonate preparation cycle was completed; the estimated yield was 75,000 Ci. This material was put in temporary storage while another cesium-137 accumulation cycle was run. Another cesium carbonate run is now in progress. This run, together with the previously stored carbonate, should provide about 150,000 Ci of material to be converted to $^{137}CsCl$ during December.

It is expected that the last of the stored unpurified cesium-137 will be brought into the mainstream crystallizer system early in December. There should then be enough cesium-137 in the system for two oxalate/carbonate cycles. Since the oxalate process is a recycle procedure, the last filtrates will have to be scavenged by the ammonium alum carrier procedure at least once. A significant amount of cesium-137 (probably ∿25,000 Ci) will remain in the crystallizer system after the scavenging. This residual cesium-137 will be recovered by special methods if economically feasible; if not, it will be transferred to the intermediate level waste.

The current cesium-137 process status is shown below.

Item	Cesium-137 (Ci)
In-process material	570,000
$^{137}CsCl$ products	316,000
Sources in fabrication	33,300
Completed sources awaiting shipment	182,500

2. Operational Summary

Item	Nov. 1972		CY 1972		FY 1973	
	No.	Ci	No.	Ci	No.	Ci
HAPO shipments received	0	0	0	0	0	0
Product batches prepared	0	0	31	314,000	30	307,000
Sources						
Fabricated	6	300	29	55,600	6	300
Shipped	6	300	29	55,600	6	300
Special form cans						
Fabricated	0	0	20	114,400	10	500
Shipped	0	0	8	1,900	3	1,000

3. Current Orders

Current orders for cesium-137 as sources or bulk powder are shown below:

	Amount (Ci)	Estimated Shipping Date
Brookhaven National Laboratory	203,000	FY 1973
Lockheed-Georgia Company	∿35,000	a
Atomic Energy of Canada Limited	25,200	December 1972
Technical Operations, Inc.	150	December 1972
J. L. Shepherd Associates, Inc.	14,754	December 1972

[a]Sources are in storage awaiting receipt of customer's container.

An order is on hand from Atomic Energy of Canada Limited for 88,000 Ci of cesium-137 as CsCl powder. The powder has been canned and stored awaiting release by AECL.

4. Source Fabrication

The following cesium-137 sources were shipped during the month ending November 20, 1972.

Customer	Type	No. of Sources	Total Curies
Technical Operations	Type III, Radiographic	2	100
Technical Operations	Type I, Radiographic	1	8
Gamma Industries	Type I, Radiographic	3	30

Strontium-90 Pilot Production *(R. W. Schaich)*

1. Process Status

No strontium-90 processing was done. The current strontium-90 process status is shown below.

Item	Strontium-90 (Ci)
In-process material	805,900
Strontium-90 products	426,200
Sources in fabrication	0
Returned SNAP sources	446,600
Completed sources awaiting shipment	221,000

2. Operational Summary

Item	Nov. 1972 No.	Nov. 1972 Ci	CY 1972 No.	CY 1972 Ci	FY 1973 No.	FY 1973 Ci
HAPO shipments received	0	0	0	0	0	0
Product batches prepared	0	0	13	510,000	0	0
Sources						
Fabricated	0	0	9	581,000	0	0
Shipped	0	0	5	360,000	0	0
Special form cans						
Fabricated	0	0	39	5,600	0	0
Shipped	1	10	14	900	1	10

3. Current Orders

Current orders for strontium-90 as sources or bulk powder are shown below:

Item	Amount (Ci)	Estimated Shipping Date
U. S. Navy (ORNL)	221,000	FY 1973
U. S. Navy	278,675	a

[a]To be released by customer.

4. Source Fabrication

Ten curies of strontium-90 powder was shipped to General Radioisotope Products.

Short-Lived Fission Products Pilot Production
(Production and Inventory Accounts) *(R. W. Schaich)*

Isotope	Number of Batches	Amount (Ci)
Iodine-131	2	48
Xenon-133	2	700

Promethium-147 Shipments and Current Orders *(R. W. Schaich)*

A shipment of 12,430 Ci of powder was made to Atomic Energy of Canada Limited.

SOURCE DEVELOPMENT — 08-01-04

Americium-241 *(F. N. Case)*

1. Annular Source for Vanderbilt

Reencapsulation of the americium-241 annular source supplied to Vanderbilt Medical Center for use in thyroid scanning of stable iodine by x-ray fluorescence has been reviewed as a possible method for increasing the efficiency of producing the fluorescence x-rays. Capsules have been designed, and reencapsulation work is planned for December 1972 or January 1973. Several small sources will be made from the single source in order that a movable array can be assembled into the collimator/detector unit used for the thyroid scanning.

2. Oil Well Application

Americium-241 sources able to tolerate high pressures (30,000 psi) are used in oil well applications. Since thin windows are also necessary, pellets of americium-241 to be encapsulated must support the windows to prevent their collapse. Tests were made using stable rare-earth oxides in which a combination of silicon, aluminum, and rare-earth oxides was blended and pressed into a pellet. When the compacted mixture is heated to ∿800°C a thermite reaction occurs to produce a dense ceramic composition that will survive 30,000 psi hydrostatic pressure.

Future work will involve the fabrication of a pellet using americium-241 and determining its output and chemical stability.

Radioisotope Characterization, Quality Control, and Standards *(S. A. Reynolds)*

1. Radioisotope Characterization

Our efforts to improve the availability of decay-scheme information have resulted in scheduling a panel discussion during a session on gamma measurements sponsored by ANS-16 and the Isotopes and Radiation Division. This will take place at the next summer meeting of the Society, and the panel will include users and compilers of nuclear data. Another effort involves communication with the NBS Office of Standard Reference Data.

Silver-110m calibrations and decay-scheme information were reviewed. There is an accepted decay scheme for silver-110m (ORNL Nuclear Data Group). For silver-111, the principal gamma radiation occurs in about 6% of the disintegrations (as listed in the *Isotope User's Guide*), but two compilers have selected 4.6 and 8%; continued use of 6% was recommended for the time being.

2. Radioisotope Special Analysis and Quality Control

ANS-16 continues to be concerned with enlarging membership and with establishing liaison with organizations having similar interests. These include ANSI and ASTM committees and subcommittees of NRC and AIF concerned with radioactivity standards. We continue to supply technical back-up to these committees; for example, an ANSI representative contacted us on behalf of a subcommittee of ISO TC-85 concerning problems with liquid scintillation counting, for which we were able to supply the necessary information.

RADIOISOTOPE SALES

(J. E. Ratledge)

ITEMS OF INTEREST

An order was received from Measurex Corporation for 300 Ci of enriched krypton-85 (∿41%). Requests for quotation were received from the following: Messerschmitt-Bolkow-Blohm, Germany, for a 300-W_t (∿44,000 Ci) strontium-90 source; Isomedix, Inc., for thirty cesium-137 sources each containing ∿3,000 Ci; Eon Corporation for 320 cesium-137 sources each containing 25 mCi and 80 cesium-137 sources each containing 20 μCi; and Gamma Industries, Inc., to impregnate glass beads with cesium-137.

Shipments made during the month that may be of interest are listed below:

Customer	Isotope	Amount
Large Quantities		
Radium-Chemie A. Zeller and Company	Tritium	10,000 Ci
U. S. Radium Corporation	Tritium	10,000 Ci
New England Nuclear Corporation	Tritium	4,000 Ci
Schwarz Bioresearch, Inc.	Tritium	1,500 Ci
Donald W. Douglas Laboratory	Promethium-147	50,000 Ci
Withdrawn Items		
Mayo Clinic	Copper-67	2 lots
University of Pittsburgh	Iodine-131	50 mCi
University of Rochester	Iodine-131	450 mCi
Cleveland Metropolitan General Hospital	Iodine-131	50 mCi
Items Used in Cooperative Programs		
Oak Ridge Associated Universities	Gallium-67	∿300 mCi
Nagoya University, Japan	Europium-156	∿7 mCi
Max-Planck Institut fur Kernphysik, Germany	Europium-152	∿1 mCi

A summary of radioisotopes shipped during November 1972 is given in Table 2.

Table 2. Summary of Radioisotopes Shipped During November 1972

Radioisotope	Number of Shipments	Quantity (mCi)
Argon-37	1	1
Calcium-47	10	7
Cerium-144	1	10
Cesium-137	6	146,000
Cobalt-60	1	25
Copper-67	2	13
Gross Fission Products	1	5
Hafnium-181	1	2
Indium-114	1	3
Iodine-129	1	550[a]
Iodine-131	4	560
Iridum-192	1	1
Krypton-85, normal	14	255,035
Krypton-85, enriched	1	50,000
Lead-203	1	5
Niobium-95	3	11
Phosphorus-33	5	105
Potassium-43	6	21
Promethium-147	21	500,000
Ruthenium-103	2	5
Ruthenium-106	3	17
Samarium-151	1	20[a]
Strontium-89	5	36
Technetium-99	1	6[a]
Tritium	11	26,512,000
Xenon-133	61	63,220
Zirconium/Niobium-95	3	17
Misc. compound preparations	5	192
Radioisotope targets	2	
Cyclotron service irradiations		
Cobalt-57[b]		∿2,000
Cobalt-57[c]		290
	175	27,529,581
		576[a]

[a]Milligrams.

[b]For New England Nuclear Corporation.

[c]For N. V. Philips-Duphar.

The radioisotope sales proceeds and shipments for the first four months of FY 1972 and FY 1973 are given in Table 3.

Table 3. Radioisotope Sales and Shipments

Item	7-1-71 thru 10-31-71	7-1-72 thru 10-31-72
Inventory items	$131,114	$115,055
Major products	18,750	18,588
Radioisotope services	103,367	44,172
86-Inch Cyclotron irradiations	47,085	29,091
Miscellaneous processed materials	25,377	19,325
Packing and shipping	24,205	21,985
Total	$349,898	$248,216
Number of Shipments	869	685

ADMINISTRATIVE

Travel of IDC members and visitors to the IDC are given in Tables 4 and 5, respectively.

Table 4. Travel by IDC Personnel

Traveler	Site Visited	Purpose of Visit
P. S. Baker	Deland and Boca Raton, Florida, and Waco, Texas	Traveling lecture program
L. C. Brown	Los Alamos, New Mexico	Attend LAMPF Users' Group meeting
L. C. Brown and J. K. Poggenburg	Atlanta, Georgia	Attend Society of Nuclear Medicine Annual meeting
R. A. Robinson, K. W. Haff, and R. E. McHenry	Washington, D. C.	Attend and present paper at Nuclear Society Winter meeting
S. A. Reynolds	Washington, D. C.	Attend ANS meeting
J. J. Pinajian	Dartmouth Hanover, New Hampshire	Participate in oral presentation of Doctorate of Engineering thesis for guest student

Table 5. Visitors to IDC

Visitor	Affiliation	Purpose of Visit
F. K. Manasse	Drexel Institute of Technology	Give lecture "Future Trends in Bioengineering Device Research" Contact: J. H. Gillette
Lothar A. Wiesner	Systec Systemplonung und Industrieberatung GmbH Dusseldorf, Germany	Discuss applications of curium-244, availability of cesium-137 and strontium-90, and use of radioisotopes in industry

PUBLICATIONS

REPORTS

J. H. Gillette, *Isotope Program (5000) Progress Report for Quarter Ending September 30, 1972*, ORNL-TM-4025, Oak Ridge National Laboratory.

Eugene Lamb, *ORNL Isotopic Power Fuels Quarterly Report for Period Ending September 30, 1972*, ORNL-4840, Oak Ridge National Laboratory.

Eugene Lamb, *Isotopic Power Fuels Monthly Status Report for October 1972*, ORNL-TM-4035, Oak Ridge National Laboratory.

A. F. Rupp, *Radioisotope Program (8000) Progress Report for October 1972*, ORNL-TM-4043, Oak Ridge National Laboratory.

INTERNAL DISTRIBUTION

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