Pacific Northwest Laboratories
Richland, Washington 99352

~~OFFICIAL USE ONLY~~

This report is intended primarily for internal use by the sponsoring organization and Battelle.

PACIFIC NORTHWEST LABORATORY
MONTHLY REPORT TO THE
DIVISION OF ISOTOPES DEVELOPMENT
FOR APRIL 1971

[illegible]

MASTER

OFFICIAL USE ONLY

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

PATENT STATUS

This document copy, since it is transmitted in advance of patent clearances, is made available in confidence solely for use in performance of work under contracts with the U. S. Atomic Energy Commission. This document is not to be published nor its contents otherwise disseminated or used for purposes other than specified above before patent approval for such release or use has been secured, upon request, from the Chief, Chicago Patent Group, U. S. Atomic Energy Commission, 9800 So. Cass Avenue, Argonne, Illinois, 60439.

PRELIMINARY REPORT

This report contains information of a preliminary nature prepared in the course of work under Atomic Energy Commission Contract AT(45-1)-1857. This information is subject to correction or modification upon the collection and evaluation of additional data.

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately-owned rights.

PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE MEMORIAL INSTITUTE
for the
U. S. ATOMIC ENERGY COMMISSION
Under Contract AT(45-1) 1830

PACIFIC NORTHWEST LABORATORY
MONTHLY REPORT TO THE
DIVISION OF ISOTOPES DEVELOPMENT
FOR APRIL 1971

Compiled by J. E. Hansen

May 15, 1971

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission nor any of their employees nor any of their contractors, subcontractors, or their employees makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

*This report is intended primarily for internal use
by the sponsoring organization and Battelle-Northwest.*

fy

DISTRIBUTION - OFFSITE

Division of Biology and Medicine, USAEC, Washington, D.C.

J. D. Goldstein

Division of Isotopes Development, USAEC, Washington, D.C.

W. E. Mott

O. M. Bizzell

J. E. Machurek

R. L. Butenhoff

D. W. Cole

F. D. Haines

R. W. Shivers

J. N. Maddox

W. S. Holman

Division of Reactor Development & Technology, USAEC, Washington, D.C.

G. W. Cunningham

M. Shaw

Chief, Isotopic Auxiliary Power Branch

Division of Space Nuclear Systems, USAEC, Washington, D.C.

R. T. Carpenter

G. A. Newby

G. P. Dix

J. A. Powers

M. Klein

F. C. Schwenk

Mound Laboratory, Monsanto Corporation, Miamisburg, Ohio

W. T. Cave

R. L. Neubert

Oak Ridge National Laboratory, Oak Ridge, Tennessee

P. S. Baker

J. H. Gillette

A. F. Rupp

E. E. Beauchamp

Oak Ridge Operations Office, USAEC, Oak Ridge, Tennessee

D. C. Davis, Jr.

Richland Operations Office, USAEC, Richland, Washington

B. A. Ryan

Savannah River Laboratory, Aiken, South Carolina

D. H. Turno

Savannah River Operations Office, USAEC, Aiken, South Carolina

W. D. Sandburg

DISTRIBUTION - ONSITE (BNW)

E. L. Alpen
J. L. Bates/T. D. Chikalla
J. M. Batch
F. T. Cross
G. J. Dau/J. B. Vetrano
J. L. Deichman
D. E. Deonigi
K. Drumheller
J. W. Finnigan/R. S. Kemper
H. T. Fullam
V. L. Hammond
J. E. Hansen (2)
A. J. Haverfield
J. H. Jarrett
R. W. McKee
J. E. Minor
L. K. Mudge
R. E. Nightingale
R. W. Perkins
F. P. Roberts
C. A. Rohrmann
K. J. Schneider
J. C. Sheppard
K. L. Swinth
H. H. Van Tuyl
E. J. Wheelwright
N. A. Wogman
Technical Files (3)

PACIFIC NORTHWEST LABORATORY
MONTHLY REPORT TO THE
DIVISION OF ISOTOPES DEVELOPMENT
FOR APRIL 1971

08-01. RADIOISOTOPES PRODUCTION AND
MATERIALS DEVELOPMENT

08-01-03. FISSION PRODUCTS

I. LOW COST CESIUM AND STRONTIUM SOURCES - H. H. Van Tuyl

The objective of this program is to provide technology for the production of inexpensive Cs and Sr sources by using the purified compounds generated in the Hanford Waste Management Program (HWMP). Large scale use of these radioisotopes will require an assessment of the capabilities of HWMP for producing suitable radiation and heat sources, acceptance of the HWMP product by the customer, licensing of the sources, and market development activities.

The goal in FY-1971 is to develop equipment for fabricating smaller diameter sources in the HWMP facility. The incremental cost of producing smaller sources will be evaluated. Prototype sources will be fabricated with nonradioactive feeds, including loading capsules, welding, and NDT. The sources will be tested to determine mechanical integrity. Potential customers will be contacted to stimulate interest in the HWMP sources.

Construction has been started by ARHCO on the encapsulation portion of the Waste Management plant. The facility is expected to be ready for cold testing in CY-1973, and for full hot operation in January 1974. Ion exchange purification equipment for cesium is being installed in B-Plant, and final purification of cesium is expected to start in FY-1972.

Final strontium purification is progressing satisfactorily, and improved flowsheets are being developed. Good product purity can be achieved even with existing technology. One of the strontium product tanks contains about 12 MCi of strontium of 95% chemical purity. The ^{90}Sr content is 53.7 w/o based on total cation content. This material is better than any solvent extraction material previously shipped to ORNL.

At the present processing rate, the waste storage tanks will have been completely processed in about 1976. A few additional years will probably be required for conversion to solids and encapsulation.

II. UTILIZATION OF FISSION PRODUCTS Rh, Pd, Ru, and Tc

The traditional view of fission products as waste materials has been supplanted by their role as a national resource. Pursuant to this revised status, a resource strategy is now being formulated to direct optimum technological and economic application of the fission products Rh, Pd, Ru, and Tc created in operation of nuclear power reactors. This program seeks to evaluate the potential of these artifacts as supplements to the natural reserve of precious metals, and emphasizes the practical aspects of their safe use. The program comprises the following tasks:

- 1. Evaluation of rhodium and palladium produced in power reactors.*
- 2. Technology for recovery of Rh, Pd, Tc, and Ru.*
- 3. Market analysis of Rh, Pd, Tc, and Ru.*
- 4. Economic analysis of Rh, Pd, Tc, and Ru production from nuclear wastes.*
- 5. Fabrication process development for nuclear source (Rh, Pd, Tc, and Ru) products.*

A. Radiation Characteristics -- F. P. Roberts

1. ^{102m}Rh Half-Life -- Nothing to report.
2. Isotopic Composition of Rh in Spent Reactor Fuels -- Nothing to report.
3. Dose Rate from Fission Product Palladium -- The dose rate from massive pieces of fission product palladium are expected to be very low because of the short range of the beta particle emitted in the decay of ^{107}Pd . In order to verify this a source has been prepared by plating 0.49 g of highly purified fission product palladium on a 3 in. x 3 in. nickel foil. This gives a palladium thickness of 8.4 mg/cm^2 which greatly exceeds the range of the ^{107}Pd beta. The plate can, therefore, be treated exactly as if it were an infinitely thick slab of palladium for dose rate measurement.

The actual dose rate determination will be made by the Radiation Calibrations Section using their extrapolation chamber. This chamber has a window with a thickness of 7 mg/cm^2 which is the normal thickness of the human skin. The measured dose will, therefore, be the dose received through the skin. Also, the dose rate will be measured without the window to determine the unshielded value.

B. Fabrication Process Development -- R. G. Nelson

Nothing to report.

C. Market Analysis -- J. C. Sheppard

Nothing to report.

III. EVALUATION OF LARGE SCALE USES FOR PURIFIED FISSION PRODUCTXENON - C. A. Rohrmann

Of all the fission products, Xe has the highest fission yield. Although many of the Xe isotopes are radioactive, they all have such short half lives that their activity would be insignificant after allowing time for normal fuel reprocessing.

In the past, the extreme rarity of Xe in nature has clearly inhibited its consideration for specific large scale uses even where its properties give it definite and unique advantages. But now, Xe could be made available in surprisingly large quantities. Perhaps the most important and beneficial uses of Xe would be for human surgical anesthesia. Another of the potential uses is a filler gas in incandescent light bulbs with significant increase in both brightness and efficiency.

The scope of the PNL program is to: (1) establish the quality of Xe which can be accepted or generally licensed for consumer uses, (2) determine what industries would be interested in evaluating fission product Xe for large scale application, (3) distribute specimens to participating evaluators, (4) compile evaluation results, and (5) prepare a final report on the results of this total effort.

The stock of low-⁸⁵Kr fission product xenon at ORNL is planned to be treated primarily for the elimination of gross amounts of water vapor, carbon dioxide (carbon monoxide), and oxygen. The equipment for the processing has been set up and will be operated early in the next period.

IV. ISOTOPE PRODUCTION EVALUATIONS - R. W. McKee, B. M. Cole,
and R. G. Rau

This program is designed to evaluate major aspects of isotope production. Until recently, the principal source of isotopes has been the AEC production reactors. Now, however, power reactors are rapidly becoming important sources of isotopes. Power reactors also offer attractive prospects for target irradiations. The future availability and cost of these unique isotopes depend on full and efficient utilization of the production potential of power reactors, and the inherent value of these materials can have a significant impact on nuclear power costs.

The scope of this program includes analysis of fast and thermal reactor fuel cycles within the framework of an expanding nuclear power industry to identify the sources, quantities, timing and cost of production of isotopes of potential importance.

A new task to develop an Isotope Data System was initiated in FY-1971. The objective is a computerized, quick-response system for answering queries on isotope properties, availability, applications, shielding requirements, decay compositions, toxicity, and other factors.

A. Fission Product Profitability Studies

Previously reported results from this study (see BNWL-B-36) have shown that an established and substantial market will be required before fission product Cs-137 could be profitably recovered from spent power reactor fuels. Also, recovery of both Cs-137 and Sr-90 as co-products was shown to provide a substantial advantage. Calculations have now been completed for a series of cases simulating the development of a Cs-137 and Sr-90 recovery business

where the gradually developing market is first supplied from Cs and Sr recovered in the Hanford Waste Management Program (HWMP) facility (scheduled for 1973 completion). A private reprocessor then commences recovery after the market has been established. The calculations were carried out using a series of computer programs developed specifically for this simulation.

Two fundamental modes for phasing out the HWMP source of supply have been considered. One assumes a gradual phase-out over a five-year period and the other assumes an abrupt termination of the HWMP source as soon as a private reprocessor begins operating. The cesium-137 market is defined in terms of its share of the overall radiation source market (based on a separate AECOP study), which share grows from 10% in 1973 to a maximum of 50% in 1980 and beyond.

Three market projections identified as Base (low), Medium, and High, have been considered in the case of Cs-137, whereas only two projections, identified as Base (low) and High have been considered in the case of Sr-90. These market assumptions are shown in Figures 1 and 2.

The calculations result in defining the encapsulated product price required for a given set of conditions. The results presented here are all based on requiring a 15% return on investment after taxes and a 10-year economic life (the effect of varying these parameters as well as other important variables has been calculated in all cases but is not reported here). Each calculated price represents the price for an optimum size plant for that specific set of conditions. A learning curve allowance is also included in the calculation.

The calculated price required is the levelized price, or the single price that results in the specified return over the economic life.

FIGURE 1: Total Gamma Radiation Market Projections As Co-60 Requirements Including Source Replenishment Requirements

FIGURE 2 Strontium-90 Market Projections

Results are summarized in Tables 1 and 2 for Cs-137 and Sr-90 respectively when the HWMP sales are phased out gradually. Tables 3 and 4 summarize results when HWMP sales are phased out abruptly at the startup of private recovery facilities.

The abrupt HWMP-sales phase-out is advantageous to the feasibility for private recovery facilities. For the base market projection, however, even with this advantage, considering that the probable value of power reactor Cs-137 lies between 25 and 30¢/ci (see BNWL-B-61), recovery of Cs-137 from power reactor fuels appears only marginally feasible in the 1980-82 time period.

For the higher market projections, Cs-137 recovery from power reactor fuels could be attractive by 1977 and the market could support two or more competitors by the early 1980's.

Even though there is no relationship between the Cs-137 and Sr-90 market projections, the price requirements are surprisingly similar. The probable value range for Sr-90 has not been identified but it is probably not more than 35 to 40¢/ci for large scale uses to develop. The results in Tables 2 and 4 indicate Sr-90 could be priced in the range of 25-30¢/ci when recovered on a co-product basis with Cs-137 at the time when Cs-137 recovery is feasible. Thus co-product recovery does appear feasible.

B. Nuclide Tables

Preparation of the 2000 plus data cards containing the daughter nuclide and reference data has been completed. Incorporation of this data in the Table II compilation has been delayed by unanticipated programming changes. Some checking and correcting of the data file has been carried out but a good deal more remains to be done.

TABLE 1

CESIUM-137 PRICE REQUIREMENTS FOR CO-PRODUCT BASIS
AND GRADUAL PHASE-OUT OF HWMP SALES

Market Projection	<u>Base (Low)</u>			<u>Medium</u>			<u>High</u>		
Startup Year for Power Reactor Cs-137 Recovery	1977	1980	1982	1977	1980	1982	1977	1980	1982
Price Required, ¢/ci									
With One Processor	45	41	37	33	29	27	26	22	19
With Two Processors	74	66	61	52	46	42	41	33	28

TABLE 2

STRONTIUM-90 PRICE REQUIREMENTS FOR CO-PRODUCT BASIS
AND GRADUAL PHASE-OUT OF HWMP SALES

Market Projection	<u>Base (Low)</u>			<u>High</u>		
Startup Year For Power Reactor Sr-90 Recovery	1977	1980	1982	1977	1980	1982
Price Required, ¢/ci						
With One Processor	46	38	34	31	25	23
With Two Processors	76	61	55	49	38	34

TABLE 3

CESIUM-137 PRICE REQUIREMENTS FOR CO-PRODUCT BASIS
AND ABRUPT PHASE-OUT OF HWMP SALES

Market Projection	<u>Base (Low)</u>			<u>Medium</u>			<u>High</u>		
	1977	1980	1982	1977	1980	1982	1977	1980	1982
Startup Year For Power Reactor Cs-137 Recovery									
Price Required, ¢/ci With One Processor	37	29	26	27	21	19	22	17	15
With Two Processors	60	46	42	42	32	29	34	24	21

TABLE 4

STRONTIUM-90 PRICE REQUIREMENTS FOR CO-PRODUCT BASIS
AND ABRUPT PHASE-OUT OF HWMP SALES

Market Projection	<u>Base (Low)</u>			<u>High</u>		
	1977	1980	1982	1977	1980	1982
Startup Year For Power Reactor Sr-90 Recovery						
Price Required, ¢/ci With One Processor	36	28	26	25	19	17
With Two Processors	59	45	40	39	29	25

OFFICIAL USE ONLY

-11-

BNWL-B-95

V. PROMETHIUM-146 BURNOUT -- J. C. Sheppard

The objective of the ^{146}Pm burnout program is to estimate by computation the technical feasibility of significantly reducing the ^{146}Pm content in promethium heat source material by neutron irradiation and the extent to which it can be done. The goal will be to establish the irradiation conditions and target matrix necessary to produce promethium containing less than 0.1 ppm ^{146}Pm .

Much recent effort was devoted to the examination of literature related to γ, n and $n, 2n$ reactions in Np and Pm. Data for $n, 2n$ reactions in the rare earth region indicate that the ^{147}Pm ($n, 2n$) ^{146}Pm reaction has a cross section of about 5 millibarns for neutrons greater than 7.7 mev. This cross section is too crude to make an estimate of the fission spectrum weighted cross section. However, it is comparable to the 15 millibarn value observed for the $^{237}\text{Np}(n, 2n) ^{236}\text{Np}$ reactions.

Information on the $^{147}\text{Pm}(\gamma, n) ^{146}\text{Pm}$ reaction is slightly better. In the rare earth region the giant resonance for γ, n reaction occurs near 14 Mev, has a width at half maximum of about 5 Mev, and a maximum cross section of 400 millibarns. From these data the $^{147}\text{Pm}(\gamma, n) ^{146}\text{Pm}$ cross section is estimated to be about 5 millibarns for gammas greater than 7.7 Mev. The uncertainty in this estimate is how rapidly the cross section changes with increasing gamma energy.

These estimates of the cross sections will provide the basis for estimating the extent of ^{146}Pm burnout in the presence of ^{147}Pm . Computations using these cross sections to estimate optimum irradiation conditions are being made.

Considerable data are available from Savannah River and Hanford irradiations of ^{237}Np to produce ^{238}Pu containing low levels of ^{236}Pu . Both Hanford and Savannah River have produced ^{238}Pu containing 0.15 ppm ^{236}Pu . This reduction of the ^{236}Pu level by a factor of seven or eight was achieved largely by the proper choice of target matrix (graphite or zirconium) to minimize the high energy gamma flux within the target and by location of the target in a reactor position that reduced contributions from fast neutrons and high energy gammas.

The approach used for ^{236}Pu is directly applicable to the ^{146}Pm burnout experiments because the $^{147}\text{Pm}(\gamma, n)$ ^{146}Pm and $^{147}\text{Pm}(n, 2n)$ ^{146}Pm contribute significantly to the production of ^{146}Pm . Further examination of Hanford and Savannah River ^{238}Pu data revealed the following:

1. Structural parts (walls) of the Savannah River reactors make large contributions to the production of ^{236}Pu via the $^{237}\text{Np}(\gamma, n)$ ^{236}Np reaction. These high energy gammas ($>8\text{Mev}$) are produced by n, γ reactions on Fe, Cr, and Ni. This gamma flux decreases linearly with distance from the reactor wall. This suggests the obvious approach of performing irradiations as far from the walls as possible.
2. As mentioned above, it is very important to use a target matrix that does not produce high energy gammas. Savannah River has shown that, in addition to zirconium and graphite, magnesium should be a good target matrix. They have also shown that when aluminum must be used the amount should be kept to a minimum. The contribution of ^{236}Pu from the aluminum matrix was almost proportional to the amount of aluminum present - a 38 percent reduction in the amount of aluminum present resulted in a 33 percent reduction in the ^{236}Pu level.

3. Savannah River data indicate that the γ, n reaction contributes 90 percent of the ^{236}Pu under optimum irradiation conditions.
4. Iron, nickel, and chromium impurities in aluminum cladding can increase the ^{236}Pu levels by about ten percent.
5. Savannah River has considered bismuth as target shielding material. Use of one inch of bismuth (and presumably lead) would reduce the γ, n production of ^{236}Pu from external (wall, etc.) sources by one fourth.

There is a direct correspondence between the above observations and the ^{146}Pm burnout experiments because the contaminants come from γ, n and $n, 2n$ reactions which differ only in the reaction thresholds and cross sections. Rough calculations indicate that irradiation conditions that produce one ppm ^{236}Pu in ^{238}Pu should produce promethium containing <0.5 ppm ^{146}Pm on a weight basis (<0.25 ppm on a disintegration basis). Since Savannah River has developed extensive data on optimum ^{238}Pu irradiations, the promethium data were normalized to the ^{238}Pu data to demonstrate the importance of the various contributions (distance, target matrix, $n, 2n: \gamma, n$, etc.). The results of this normalization are shown in Tables 5 and 6.

Computations have been started to determine the maximum high energy gamma flux that can be allowed to achieve a desired ^{146}Pm burnout of about eighty percent. This will be done for a series of initial ^{146}Pm levels, ranging from power reactor material (~ 3.5 ppm) to Hanford and Savannah River material (~ 0.25 ppm), and for several assumed ^{146}Pm cross sections.

Table 5ppm ^{146}Pm in Promethium-Aluminum Matrix

Distance from Reactor Center, cm	163	210	222	235
$^{147}\text{Pm}(n,2n)^{146}\text{Pm}$	0.03	0.01	0.006	0.003
$^{147}\text{Pm}(\gamma,n)^{146}\text{Pm}$ external	0.02	0.03	0.05	0.18
$^{147}\text{Pm}(\gamma,n)^{146}\text{Pm}$ internal	0.07	0.07	0.07	0.07
TOTAL	0.12	0.11	0.13	0.25

Table 6ppm ^{146}Pm in Promethium-
Graphite (or Zirconium, or Magnesium) Matrix

Distance from Reactor Center, cm	163	210	222	235
$^{147}\text{Pm}(n,2n)^{146}\text{Pm}$	0.03	0.01	0.006	0.003
$^{147}\text{Pm}(\gamma,n)^{146}\text{Pm}$ external	0.02	0.03	0.05	0.18
$^{147}\text{Pm}(\gamma,n)^{146}\text{Pm}$ internal	0.01	0.01	0.01	0.01
TOTAL	0.06	0.05	0.07	0.19

08-01-04. SOURCE DEVELOPMENTI. NONDESTRUCTIVE TESTING OF SOURCESA. Neutron Radiography Using ^{252}Cf -- K. L. Swinth

The objective of this program is to develop and investigate low-flux neutron radiography techniques and applications using ^{252}Cf . Previous efforts have led to the development of a portable shield and exposure facility for ^{252}Cf thermal neutron radiography. Evaluation of this facility is underway and will lead to recommendations for future designs. Applications of ^{252}Cf neutron radiography will be identified and efforts will be identified and efforts will be extended to fast neutron radiography.

The major effort in the program is development of techniques for low-flux imaging. A position-sensitive proportional counter is under development that provides for instantaneous readout of data representing the imaged object. Various converter foils, such as Eu and ^6LiF thermoluminescent foils, are under investigation, as a means of radiographically recording the images.

A tank for source containment and neutron radiography experiments was completed. This unit will shield a source of up to 2 mg and has provisions for remotely positioning the source to preset levels. The system allows accurate vertical positioning to evaluate various shield and collimator concepts. An order was placed for a 2 mg source for use with this facility. It is doubtful if the source will arrive this fiscal year; however, it is anticipated that the transportation costs will be funded with FY-1972 money regardless of arrival time.

A design for a new, lighter shield has been completed. This unit is aimed directly at portable neutron radiography. The shield will be adequate containment for a 250 μg source and will be

capable of handling larger sources transferred between the shield and a storage cask for radiography. A portion of the shielding will be water which can be removed to implement positioning of the shield.

The position-sensitive counter is presently undergoing preliminary testing with an alpha source. The electronics are functioning properly and as soon as the converter foil is completed, tests with neutrons will commence. Tests on a previous one-dimensional prototype indicated that excellent resolution could be obtained. With a collimated alpha source a resolution of 4 mm FWHM resulted. Calculations indicate this is exactly what one would expect from the limits imposed by the collimator.

II. TECHNOLOGY PUBLICATIONS - E. J. Wheelwright

The objective of this program is to provide technology for the use of Pm as a radioisotope heat source in aerospace or terrestrial applications. In the past, the program has included development of scientific and engineering data pertinent to: (1) the purification of Pm and conversion to a useful fuel form, (2) the design and fabrication of Pm heat sources and (3) hazards analyses associated with radioisotopic heat sources. Presently, principal emphasis of the program is directed to the dissemination of Pm technology to the technical and scientific community.

The FY-1971 goal is to complete arrangements for the publication of a book on Pm technology.

Technical editing and graphics work on the promethium technology book have been initiated. Some major changes in the order of presentation are planned for Chapters 1, 2, and 3 to satisfy review comments. Minor changes will be made in other chapters to tie them together in a more coherent manner and to minimize redundancy.

III. ADVANCED SOURCE DEVELOPMENT - J. H. Jarrett

A. Advanced Alpha-Photon Source Development

The objective of this program is to evaluate present and future heat and radiatic source application requirements and to relate them to present and future encapsulation technology.

The goal of the current work is concerned primarily with the development of thin-film encapsulation and evaluation techniques for alpha/photon sources. Emphasis will be directed toward the technique of sputtering as a means to obtain thin films of radioisotope and containment materials.

Source testing at ORNL has been completed on the four PNL alpha-photon sources that were prepared in December 1970. Indications are that source performance in most tests was improved over previous PNL alpha-photon sources, tested in early FY-1971. Some areas for improvement were identified, such as isotope containment when the source is heated to over 900 °C in air. A detailed analysis will be made when ORNL documentation on the tests has been distributed. Preliminary indications are that it may be advisable to discontinue using copper in the $^{241}\text{AmO}_2\text{-Cu}$ active layer and replace it with a material such as Inconel 600. Copper is reactive with oxygen at higher temperatures and the copper oxide layer formed often adheres poorly to the copper base material. This could contribute to contamination release.

A new improved tuning network was procured for the glovebox sputtering system. Installation in May is anticipated. The new network will significantly improve experimental efficiency in the glovebox sputtering system.

08-02. THERMAL APPLICATIONS

08-02-01. CIRCULATORY SUPPORT SYSTEMS

The main objective of this program is to determine the dose from radioisotopic heat sources suitable for circulatory support systems. This is accomplished by measuring the dose rates within and surrounding various tissue equivalent phantoms.

Part of the program concerns the prediction of the measured dose rates by the development of computational codes. The computer codes are also used in parametric studies and for the prediction of the in-phantom dose rates from sources not available for measurement.

Another part of the program concerns the development of radioisotopic blood heaters for an in vivo study aimed at assessing the combined effects of heat and radiation in Hanford miniature swine implanted with 50-W plutonium heat sources.

I. CIRCULATORY SUPPORT DOSIMETRY - F. T. Cross and J. C. Sheppard

Measurements of the neutron dose rates from the Rankine dosimetry model placed in the Remab phantom are near completion. Californium-252 is being used as a substitute for the $^{238}\text{PuO}_2^{16}$ source that will eventually be placed in the Rankine device.

Plutonium-238 neutron and ^{236}Pu photon dose rates were calculated for a 30-W source containing 0.25 ppm ^{236}Pu placed in the Rankine dosimetry model. These calculations will appear in the February-March-April Quarterly Report.

II. RADIOLOGICAL ENGINEERING STUDIES - F. T. Cross and B. D. Bingham

Engineering studies to develop radioisotopic blood heaters in support of PNL's "Biological Effects of Intracorporeal Radioisotope Heat Source" study included investigation of heater geometry, materials, and temperature changes in the bulk stream and boundary layer of the host animal blood. The conceptual design of a telemetry system for monitoring blood temperature changes was completed. Two surgical shams were fabricated and a third sham using hydraulic screw couplings to simplify surgery has been designed. The final thoracic heater design and shop drawings were completed.

08-03. RADIOISOTOPE SYSTEMS DEVELOPMENT08-03-03. OCEANOGRAPHIC AND NATURAL RESOURCE APPLICATIONSI. MARINE SYSTEMSA. Nuclear Techniques for Seabed Mineral Exploration -
R. W. Perkins and N. A. Wogman

In recent PNL studies of the composition of deep ocean sediments, it has been demonstrated that various mineral deposits and commercial-grade ores can readily be identified by neutron activation and instrumental analysis. From preliminary analysis, it is evident that the elemental composition of most mineral deposits can be easily identified at concentrations well below those of economic importance. In-place experience with Cf-252 as a neutron source has confirmed these conclusions. Two methods for in-place seabed mineral exploration are being investigated. The first involves placing a neutron source and detector system on the ocean floor. The second method involves bringing the samples on board

ship and employs a shipboard Cf-252 irradiator and a Ge(Li) spectrometer. The former technique has the advantage of very rapid analyses, and the latter technique has the advantage that mineral depth profiles can be defined from core sampling.

During the past month the seabed mockup facility, which uses a 1.8 mg ^{252}Cf neutron radiation source, was used to measure variations in mineral detection efficiency resulting from changes in mineral density, uniformity of the mineral distribution, overburden of inert material, and changes created in the neutron flux by high cross section overburdens. For the effect of density, the investigations utilized iron powder-dunite mixtures containing the elements of interest with densities ranging from 1.7 to 4.0 gm/cc. These mixtures were irradiated in the normal simulated ocean floor geometry, under 1" of overburden, and with a high cross-section overburden (containing 1% cadmium).

Gamma rays near 140 keV are attenuated by about 1.5 fold for the density 4 substrate relative to the normal density 1.7 material. A 1" overburden over a density 1.7 substrate decreases the detection of 140 keV photon emitters by about fourfold, while a 1% Cd overburden reduces the detection sensitivity somewhat more. If these elements are beneath 1" of 1% Cd overburden with a density of 1.7, their detection sensitivity is reduced 4.6 fold. Higher energy gamma-ray emitters near 1.5 Mev have their counting efficiencies reduced by about 1.4 fold as the matrix density increases from 1.7 to 4.0. These studies of measurement efficiencies with variations in sample matrix for the planned operation of the seabed nuclear probe are continuing.

PROMETHIUM INVENTORY - April 30, 1971

Received from ARHCO		<u>16,361,900 Ci</u>
Transfers and Shipments	1,498,520 Ci	
Concentrated Feed	4,708,367	
Product	None	
Unaccounted	1,144,365	
Decay	8,442,239	
Waste	568,409	
Total	<u>16,361,900 Ci</u>	

Processing and Transfers

Approximately 90,000 Curies have been processed. The exact amount will not be known until receipt of the laboratory analysis.

The product from the March promethium purification became back contaminated with gamma type fission products during storage in A-Cell or transfer to the gloved-box for conversion to oxide. A-Cell and the gloved-box were subjected to exhaustive decontamination and another purification run was completed during April to supply oxide for orders from DWDL and ORNL. Careful analysis of the two stored product fractions showed both fractions to be of high purity. The product has been converted to oxide and will be shipped as soon as analytical work on the oxide is completed.

DID BUDGET STATUS - FY-1971 Through April 30, 1971

	<u>Cost</u>	<u>Cost to Date</u>	<u>Budget</u>
08-01 <u>Radioisotope Production and Materials Development</u>			
08-01-03 Fission Products			
I. Low-Cost Cs/Sr Sources	0.5	49.3	50
II. Rhodium, Palladium, Ruthenium, and Technetium	2.2	34.1	40
III. Xenon	1.9	6.9	20
IV. Evaluation of Isotopes Production	8.6	109.0	120
V. Promethium-146 Burnout*	<u>3.2</u>	<u>3.2</u>	<u>10</u> *
Subtotal 08-01-03	16.4	202.5	240
08-01-04 <u>Source Development</u>			
I. Nondestructive Testing of Sources			
A. NDT R&D Support	0.1	25.8	25
B. Neutron Radiography	7.0	26.0	30
II. Technology Publications	0.1	19.7	20
III. Advanced Source Development	<u>0</u>	<u>46.2</u>	<u>50</u>
Subtotal 08-01-04	7.2	117.7	125
Subtotal 08-01	23.6	320.2	365

	<u>Cost</u>	<u>Cost to Date</u>	<u>Budget</u>
08-02 <u>Thermal Applications Development</u>			
08-02-01 <u>Circulatory Support Systems</u>			
I. Circulatory Support Dosimetry	7.7	74.1	85
II. Radiological Engineering Studies*	<u>14.0</u>	<u>14.0</u>	<u>30</u> *
Subtotal 08-02	21.7	88.1	115
08-03 <u>Radioisotope Systems Development</u>			
08-03-03 <u>Oceanographic and Natural Resource Applications</u>			
I. Marine Systems	<u>1.6</u>	<u>54.0</u>	<u>60</u>
Subtotal 08-03	1.6	54.0	60
Total 08 Operating Budget	46.9	462.3	540
08 Equipment Budget	<u>1.8</u>	<u>9.1</u>	<u>65</u> **
Subtotal 08	48.7	471.4	605
Pm Inventory Account	<u>40.0</u>	<u>178.4</u>	<u>210</u>
PROGRAM GRAND TOTAL	<u>88.7</u>	<u>649.8</u>	<u>815</u>

* Note: These tasks have been established on an anticipatory account basis, since the financial plan has not yet been changed.

** Note: Capital equipment costs indicate actual expenditures. \$64,000 of capital funds have been obligated by appropriation request.