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Transuranium Processing Plant Report of Production, Status, and Plans for the Period January 1, 1978—September 30, 1978

L. J. King
J. E. Bigelow
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TRANSURANIUM PROCESSING PLANT REPORT OF PRODUCTION, STATUS, AND PLANS FOR THE PERIOD JANUARY 1, 1978 — SEPTEMBER 30, 1978

L. J. King, J. E. Bigelow, and E. D. Collins

Date Published — June 1979

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ORNL-5305	Period Ending December 31, 1976
ORNL-5358	Period Ending June 30, 1977
ORNL-5415	Period Ending December 31, 1977

CONTENTS

Page

SUMMARY v

1. INTRODUCTION 1

2. PROCESSING SUMMARY AND PRODUCTION ESTIMATE 1

2.1 Processing Summary 2

2.2 Irradiation and Processing Proposals 3

2.3 Estimates of the Availability of Transuranium Elements . . . 7

3. PROCESSES AND EQUIPMENT 8

4. CALIFORNIUM NEUTRON SOURCES 9

4.1 Sources Fabricated During January 1978 — September 1978 . . 9

4.2 Used Sources Returned to TRU 9

5. SPECIAL PROJECTS 13

5.1 Purification of Americium-243 13

5.2 Enrichment of Plutonium-244 13

5.3 Production of Californium-254 14

6. DECAY AND NEUTRON CROSS-SECTION DATA 15

7. REFERENCES 17

SUMMARY

This is the 21st report in a series that is being issued to inform the heavy-element community of the status and future production plans of the Transuranium Element Production Program at ORNL. This report covers a nine-month period, whereas previous reports have been issued semiannually and subsequent reports will be issued annually. It is appropriate to extend the period covered by each report because the program has become more stable and production estimates are not subject to significant changes.

During the period January 1, 1978, through September 30, 1978, we obtained transuranium elements from 13 irradiated HFIR targets; products recovered are listed in Table 2.1. In addition, the final purifications of three batches of ^{248}Cm were completed. Forty-two product shipments were made from TRU; recipients and the amounts of nuclides shipped are listed in Table 2.2. Six HFIR targets were fabricated; each contained approximately 2 g of ^{243}Am and 7.5 g of curium.

During the next 18 months, we expect to obtain totals of 78 mg of ^{249}Bk, 835 mg of ^{252}Cf, 3.0 mg of ^{253}Es (in a mixture of isotopes), 425 μg of high-purity ^{253}Es, and 1.7 pg of ^{257}Fm; we also expect to make available 150 mg of high-purity ^{248}Cm.

During this report period, the precision of the fast-neutron counting system in the TURF Californium Facility was improved sufficiently to permit assay of the ^{252}Cf content in pellets, sources, and shipping packages. The TURF counter will be used especially for assaying packages containing large amounts of ^{252}Cf (up to 50 mg) because the counter system is heavily shielded and personnel using the system will receive relatively small exposures.

Pellets for neutron sources NSD-104 and NSD-105 were fabricated, although the encapsulations were not completed. A total of 100 neutron sources have been fabricated previously at TRU. The original and current contents (^{252}Cf and ^{248}Cm) of existing sources and the individuals to whom these sources are currently loaned are listed in Table 4.1. Three used sources were returned to TRU during this report period. Five sources were reassigned and three, containing 19, 288, and 2041 μg of ^{252}Cf, respectively, are available.

Special projects included (1) completing production of several grams of ultra-high-purity ^{243}Am, (2) final purification of 54.3 mg of high-purity ^{244}Pu, and (3) preparation of 418 pg of ^{254}Cf from 39-hr ^{254m}Es that was produced by irradiation of 14 μg of ^{253}Es.

1. INTRODUCTION

This is the 21st report in a series that is being issued to inform the heavy-element community of the status and the future production plans of the Transuranium Element Production Program at ORNL. The information presented will enable users of the products to obtain maximum service from the production facilities.

Between 1968 and 1977, 20 reports were issued semiannually. This report covers the nine-month period from January 1, 1978, through September 30, 1978, and subsequent reports will be issued annually. It is appropriate to extend the time period covered by each report because the program has become stable and estimates of production plans and schedules for the near future are not subject to significant changes. However, long-range plans can still be markedly influenced by feedback from researchers and other users of transuranium elements.

Operations during this report period are summarized, and the amounts of materials obtained and shipped are listed. Proposed processing schedules and anticipated yields of various products in the near future are outlined. The original and current contents (^{252}Cf and ^{248}Cm) of existing neutron sources made at TRU, as well as the individuals to whom these sources are currently loaned, are tabulated. Special projects to produce ultra-high-purity ^{243}Am, enriched ^{244}Pu, and enriched ^{254}Cf are described. Values of nuclear parameters that were used as input data for the calculations of production rates for transuranium elements, along with a listing of the parameters used to calculate the specific activities of the isotopes that are of interest to TRU, are included in the appendix of ORNL-5415.[1]

2. PROCESSING SUMMARY AND PRODUCTION ESTIMATE

The isotopic concentrations of the various transuranium elements are not constant but are functions of irradiation histories and decay times. We have selected one isotope of each element to use in making material balances for the isotopic mixtures normally handled. Except in special

instances, ^{242}Pu, ^{243}Am, ^{244}Cm, ^{249}Bk, ^{252}Cf, ^{253}Es, and ^{257}Fm are the isotopes used for tracing the corresponding elements. Throughout this report, we are discussing mixtures of isotopes unless we indicate otherwise.

2.1 Processing Summary

Between January 1, 1978, and September 30, 1978, the following operations were accomplished:

1. One chemical processing campaign (No. 54) was made to obtain transuranium elements from 13 HFIR-irradiated targets plus rework material. Products from this campaign are listed in Table 2.1.

2. Four batches of ^{248}Cm were purified. The first three batches (Nos. 21, 22, and 23) contained a total of 138 mg of high-purity ^{248}Cm with a specific activity of approximately 2×10^7 alpha cpm/mg; this material had been separated from the parent ^{252}Cf during earlier report periods.[1-3] The fourth batch (No. 24) was 45 mg of lesser-quality ^{248}Cm with a tenfold higher specific activity (approximately 2×10^8 alpha cpm/mg) due to a higher concentration of ^{244}Cm. The material of Batch No. 24 was obtained from rework solutions which had been accumulated during californium purification operations throughout the past three years.

3. Forty-two product shipments were made. Recipients and the amounts of nuclides shipped are listed in Table 2.2.

4. Six HFIR targets were fabricated. Each target contained approximately 2 g of americium (100% ^{243}Am) and 7.5 g of curium in the form of mixed americium curium oxide-aluminum pellets that had been pressed to 80% of the theoretical density of the pellet core. The isotopic composition of the curium in the targets was approximately 37.7% ^{244}Cm, 0.4% ^{245}Cm, 53.0% ^{246}Cm, 1.4% ^{247}Cm, and 7.5% ^{248}Cm.

Table 2.1. Amounts of materials obtained in the major campaign in the Transuranium Processing Plant during the period January 1, 1978 — September 30, 1978

	Campaign No. 54
Completion date	February 1978
Material processed	13 Cf-I Cm-HFIR targets plus rework material
Amounts obtained	
^{243}Am, g[a]	0.2
^{244}Cm, g[a]	26(71)[b]
^{249}Bk, mg	33
^{252}Cf, mg	314
^{253}Es, mg	1.6[c]
^{257}Fm, pg	0.8[d]

[a]Americium and curium are not usually separated from each other.

[b]The amount shown in parentheses is total curium.

[c]Before final purification.

[d]Estimated.

2.2 Irradiation and Processing Proposals

The level of transuranium element production is expected to continue at a rate of two processing campaigns per year. A long-term projection of the capability of the TRU-HFIR complex to produce the "yardstick" isotope ^{252}Cf was described in a previous report in this series.[4] Table 2.3 outlines the estimated production of transcurium elements from a series of likely processing campaigns that are scheduled through March 1980. Projections for the remainder of FY 1980 and FY 1981 are based on current trends.

Table 2.2. Distribution of heavy elements from the Transuranium Processing Plant during the period January 1, 1978 — September 30, 1978

Major nuclide	Date shipped	TRU file number	Shipped to: Individual	Site
^{244}Pu (99.5%), mg				
54.3	7-14-78	860	F. P. Hungate	PNL
^{243}Am, g				
0.02	2-02-78	944	R. W. Lougheed	LLL
3.1	3-13-78	756	Isotopes Research Materials Laboratory	ORNL
3.12				
^{244}Cm, g				
2.03	7-28-78	978	R. W. Hoff	LLL
21.74	9-21-78	972	R. W. Hoff	LLL
27.60	9-21-78	973	R. W. Hoff	LLL
118.34	9-22-78	967	A. R. Boulogne	SRL
169.71				
^{248}Cm (97%), mg				
23.95	4-06-78	880	J. B. Wilhelmy	LASL
3.88	7-03-78	674	R. G. Haire	ORNL
20.00	9-14-78	981	W. T. Carnall	ANL
31.74	9-14-78	982	N. M. Edelstein	LBL
11.69	9-18-78	983	R. W. Hoff	LLL
91.26				
^{249}Bk, mg				
5.73	2-03-78	945	W. T. Carnall	ANL
3.73	2-03-78	946	N. M. Edelstein	LBL
5.73	2-03-78	947	R. W. Hoff	LLL
3.73	2-10-78	949	R. G. Haire	ORNL
3.48	3-28-78	950A	M. H. Abraham	ORNL
5.921	4-03-78	964	R. G. Haire	ORNL
5.921	4-06-78	960	W. T. Carnall	ANL
5.921	4-06-78	961	N. M. Edelstein	LBL
5.921	4-06-78	962	R. W. Hoff	LLL
0.00055	4-06-78	965	F. P. Hungate	PNL
46.08455				

Table 2.2. (continued)

Major nuclide	Date shipped	TRU file number	Shipped to: Individual	Site
^{252}Cf, mg				
0.090	1-16-78	862	R. J. Gehrke	EG&G Idaho
0.132 (NS-18)	1-26-78	941	R. S. Burns	ORNL
0.115 (NS-5)	2-01-78	940	G. L. Ragan	ORNL
0.104	2-02-78	942	R. J. Gehrke	EG&G Idaho
36.583	3-13-78	931	A. R. Boulogne	SRL
5.720 (NSD-89)	5-16-78	952	R. Struss	Ames Laboratory
0.010	6-07-78	957	Isotopes Sales for	BNL
36.190	6-21-78	974	A. R. Boulogne	SRL
0.105 (NSD-15)	7-13-78	977	A. W. Blackstock	LASL
0.124 (NSD-30)	9-15-78	979	T. M. Sims	ORNL
1.989 (NZD-44)	9-20-78	976	A. M. Plummer	Battelle, Ohio
81.162				
^{254}Cf, pg				
181	5-12-78	970	J. B. Wilhelmy	LASL
237	5-19-78	971	J. B. Wilhelmy	LASL
418				
^{253}Es, μg				
625	2-10-78	954	R. G. Haire	ORNL
38	2-23-78	939	R. W. Lougheed	LLL
438	2-23-78	955	W. T. Carnall	ANL
3.3	2-23-78	956	F. P. Hungate	PNL
1104.3				
^{253}Es (milked), μg				
60	4-12-78	968	R. G. Haire	ORNL
15	4-13-78	969	Production Support	ORNL
75				
^{257}Fm, pg				
0.8	3-10-78	958	R. W. Hoff	LLL

Table 2.3. Estimated future production of transcurium elements

Period	Processing campaign	Products of campaigns				^{252}Cf production[b]		Date products available
		^{249}Bk (mg)	^{252}Cf (mg)	^{253}Es[a] (μg)	^{257}Fm (pg)	During the period (mg)	Cumulative (mg)	
Through September 1978							3106[b]	
October 1978 — September 1979	{10 Cf-I Cm-HFIR targets, 3 TRU Cm-HFIR targets}	30	330	800(75)	0.6	330	3436	February 1979
October 1979 — March 1980	{8 Cf-I Cm-HFIR targets, 5 TRU Cm-HFIR targets}	48	505	2220(350)	1.1	505	3941	February 1980
April 1980 — September 1980						300	4241	
FY 1981						600	4841	

[a]Amounts from initial separation. Amounts "milked" from californium product fraction after decay period are given in parentheses.

[b]Californium produced in SRP irradiations is not included in production totals. A total of 720 mg was recovered from 164 SRP slugs and 21 SRP tubes processed between November 1970 and January 1973.

2.3 Estimates of the Availability of Transuranium Elements

The amounts of transcurium elements expected from each campaign are shown in Table 2.3. During the next 18 months, we expect to recover a total of 78 mg of ^{249}Bk, 835 mg of ^{252}Cf, 3.0 mg of ^{253}Es (in a mixture of isotopes), 425 μg of high-purity ^{253}Es, and 1.7 pg of ^{257}Fm. The following steps were used to forecast the amounts: (1) calculation of the amounts of transcurium elements in each group of targets at the time of reactor discharge by means of our computer code, (2) addition of the assumed amounts of rework feed, and (3) application of the assumed chemical yield factors and net decay factors for the assumed recovery times to the amounts of total feed (targets plus rework). The assumed chemical yields and recovery times are based on past performance data, and the most recently revised values are given in Table 2.3 of ORNL-5305.[2]

Curium-248, a valuable research material, is formed by alpha decay of ^{252}Cf. On September 30, 1978, TRU held the inventory of purified californium shown in Table 2.4. At appropriate times, a group of packages and/or unneeded pellets or neutron sources will be processed to separate the californium and curium. The curium thus obtained is considered to be high-purity ^{248}Cm; the typical isotopic composition is 97% ^{248}Cm, 3% ^{246}Cm, and 0.01% ^{244}Cm. The ^{246}Cm is produced by the decay of ^{250}Cf, which is present in the californium. We expect to make available 80 mg of the high-purity ^{248}Cm in FY 1979 and 70 mg in early FY 1980.

Table 2.4. Inventory of purified californium-252

Container		Content on September 30, 1978	
Type	Number	^{252}Cf (mg)	^{248}Cm (mg)
Stored packages	34	945	365
^{252}Cf pellets	12	31	19
Neutron sources	80	156	238
		1132	622

3. PROCESSES AND EQUIPMENT

During this report period, the precision of the fast-neutron counting system in the TURF Californium Facility was improved sufficiently to permit assay of the ^{252}Cf content in pellets, sources, and shipping packages. Previously, the counting system was used only to make estimations of the ^{252}Cf assays because there was occasionally a large variation in successive counts made on the same package.

A series of counting experiments was made that involved four successive counts of each package or source as it was rotated 90° between counts. The standard deviation among the four counts was frequently in the range 1 to 2%. These experiments indicated conclusively that the centroid of the neutron-emitting material ($^{252}Cf_2O_2SO_4$) was not located at the axis of rotation of the source or shipping package. Thus the centroid moved closer or farther away from the detector as the source was rotated. The amount of eccentricity indicated by the variability in the count rate was calculated to be within the diameter of the source package.

A mathematical model of an eccentric source location was derived and a program was written for a programmable calculator to compute the standard deviation based on the model. When processed by the program, the standard deviations for sets of four successive counts (90° apart) fell in the range 0.13 to 0.50%. This is about the same precision as the fast-neutron system which is located at TRU and which is used to assay the ^{252}Cf content of all sources and packages shipped from TRU or transferred between TRU and TURF.

The TURF counter was calibrated over the useful range and will be used in preference to the counter at TRU for assaying packages containing large amounts of ^{252}Cf (up to 50 mg) that are transferred between the buildings. This will reduce the amount of personnel exposures incurred in making the assays because the TURF counter system is more heavily shielded.

4. CALIFORNIUM NEUTRON SOURCES

Some of the recovered californium is incorporated into neutron sources, which are subsequently loaned to researchers. Data for existing neutron sources fabricated at TRU are listed in Table 4.1. Most of the sources were fabricated into one of the four standard models illustrated in Fig. 4.1 of ORNL-4921[5] and are designated in the table by a three-letter prefix. Non-standard sources are designated simply "NS- ." The three-letter prefix indicates whether the source is singly or doubly encapsulated and whether it is fabricated from type 304L stainless steel or from Zircaloy-2. The characteristics of standard source capsules are listed in Table 4.2 of ORNL-4921.[5]

4.1 Sources Fabricated During January 1978 — September 1978

The pellets for sources NSD-104 and NSD-105 were fabricated during this report period. However, the encapsulations were not completed.

4.2 Used Sources Returned to TRU

A number of neutron sources are returned to TRU when the projects for which they are requested are completed or when replacement sources are ordered to make up for decay of the ^{252}Cf. The returned sources are available for reassignment until the appropriate time for reprocessing to recover the ingrown ^{248}Cm. During this report period, three sources were returned to TRU, five were reassigned, and three containing 19, 288, and 2041 μg of ^{252}Cf, respectively, remain in the "available" category and are so designated in Table 4.1.

Table 4.1. Data for neutron sources prepared at TRU

Source	Date of calibration	^{252}Cf content at calibration (μg)	Content as of 9/30/78		On loan to:	
			^{252}Cf (μg)	^{248}Cm (μg)	Individual	Site
NS-1[a]	8-28-68	316	22	b	K. L. Swinth	PNL
NS-2	8-23-68	275	19	b	c	
NS-3	5-13-69	∿90	∿8	b	G. I. Gleason	ORAU
NS-4	7-09-69	883	79	767	C. F. Masters	LASL
NS-5[d]	8-14-69	1,049	96	909	G. L. Ragan	ORNL
NS-6	11-21-69	747	73	642	R. W. Hoff	LLL
NS-7	1-21-70	789	81	675	F. R. Chattin	ORNL-TRU
NS-8	12-17-69	1,839	184	1,578	H. Berger	ANL
NSD-9	4-17-70	1,720	188	1,461	N. D. Wogman	PNL
NSS-10	3-11-70	113	12	b	J. P. Balagna	LASL
NS-11	3-10-70	8	1	b	R. R. Fullwood	LASL
NSS-12	6-30-70	1,868	215	1,576	R. W. Hoff	LLL
NSD-13	3-19-71	4,649	646	3,817	H. O. Menlove	LASL
NSS-14	6-29-70	4,615	531	3,895	D. C. Stewart	ANL
NS-15[e]	6-25-70	864	99	729	A. W. Blackstock	LASL
NSS-17	8-31-71	4,886	764	3,931	L. W. Dahlke	Sandia-Livermore
NS-18[d]	6-24-70	960	110	811	R. S. Burns	ORNL
NSS-19	6-26-70	493	57	416	J. E. Bigelow	ORNL-TRU
NSD-20	7-01-70	630	73	532	J. E. Powell	Sandia-New Mexico
NSS-21	10-21-70	18	2	b	F. Cross	PNL
NS-22	9-10-70	13	2	b	J. E. Bigelow	ORNL-TRU
NSD-24	10-15-70	6	1	b	J. E. Rushton	ORNL
NS-25	11-09-70	58	7	b	F. J. Muckenthaler	ORNL
NSD-26	2-11-71	14	2	b	H. O. Menlove	LASL
NSD-27	1-29-71	2,528	339	2,087	L. C. Nelson, Jr.	New Brunswick Laboratory
NSD-28	2-12-71	11	1	b	E. E. Hicks	Rocky Flats
NSD-29	9-10-71	11,393	1,794	9,153	S. G. Snow	Y-12
NSD-30	3-31-71	876	123	718	T. M. Sims	ORNL
NZD-31	11-23-71	1,731	288	1,377	c	
NZD-34	11-23-71	1,924	320	1,530	W. G. Spear	HEDL
NZD-35	11-23-71	1,896	315	1,508	N. Clark	University of Costa Rica
NS-36[d]	3-23-71	2,070	288	1,699	Y. D. Harker	EG&G Idaho
NSD-37	9-04-71	9,838	1,543	7,910	R. W. Perkins	PNL
NSD-38	6-16-71	102	15	b	H. O. Menlove	LASL
NS-39	11-07-71	942	155	751	V. Spiegel	NBS
NSD-40	4-27-72	1,154	214	896	J. P. Balagna	LASL
NSD-41	11-08-71	5,117	841	4,078	C. J. Emert	BAPL

Table 4.1. (continued)

Source	Date of calibration	^{252}Cf content at calibration (μg)	Content as of 9/30/78		On loan to:	
			^{252}Cf (μg)	^{248}Cm (μg)	Individual	Site
NSD-42	11-02-71	4,434	725	3,537	C. J. Emert	BAPL
NSD-43	4-20-72	4,839	894	3,762	C. J. Emert	BAPL
NZD-44	5-15-72	10,429	1,962	8,074	A. M. Plummer	Battelle, Ohio
NSD-45	8-18-71	1,776	275	1,431	K. L. Swinth	PNL
NSD-46	4-23-72	629	117	489	H. O. Menlove	LASL
NSD-47	7-14-71	200	30	162	P. L. Johnson	Mound
NSD-48	7-14-71	194	29	157	A. C. England	ORNL
NSD-49	7-14-71	199	30	161	L. J. Esch	KAPL
NS-50	8-23-71	138	21	111	S. G. Carpenter	ANL-NRTS
NSD-51	11-02-71	365	60	291	E. L. Benjamin	United Nuclear Industries
NSD-52	9-02-71	280	44	225	E. D. Clayton	PNL
NSD-53	10-25-71	1,051	171	839	L. J. Esch	KAPL
NS-54	1-19-73	3,187	717	2,356	V. Spiegel	NBS
NSD-55	4-19-72	4	1	b	L. J. Esch	KAPL
NSD-56	4-19-72	124	23	96	M. M. Bretscher	ANL
NSD-57	4-14-72	973	179	757	J. P. Balagna	LASL
NZD-58	5-15-72	10,849	2,041	8,399	c	
NS-59[d]	7-13-72	53	10	b	G. E. Hanson	LASL
NSD-60	4-11-72	21	4	b	F. F. Haywood	ORNL-DOSAR
NSD-61	1-19-73	5,225	1,175	3,862	L. J. Esch	KAPL
NSS-62	3-27-73	3,755	886	2,736	J. E. Bigelow	ORNL-TRU
NSD-63	4-21-72	847	157	658	H. O. Menlove	LASL
NSD-64	7-19-73	193	49	137	H. O. Menlove	LASL
NS-65	7-09-73	114	29	81	L. Green	BAPL
NSD-66	8-02-73	3,449	892	2,438	J. E. Powell	Sandia, New Mexico
NSD-67	6-07-76	13,501	7,365	5,852	H. G. Rieck	PNL
NSD-68	6-07-76	16,838	9,185	7,298	H. G. Rieck	PNL
NSD-69	6-07-76	16,775	9,151	7,271	H. G. Rieck	PNL
NSD-70	6-10-76	22,748	12,436	9,834	H. G. Rieck	PNL
NSD-71	7-15-76	21,319	11,951	8,934	H. G. Rieck	PNL
NSD-72	7-15-76	16,602	9,307	6,957	H. G. Rieck	PNL
NSD-73	9-11-73	13,545	3,607	9,478	G. I. Gleason	ORAU
NSD-74	9-11-73	4,416	1,176	3,090	G. I. Gleason	ORAU
NS-75	10-01-73	1,919	518	1,336	R. J. Kloepping	LLL
NSD-76	3-09-74	434	131	289	P. L. Johnson	Mound
NSD-77	3-09-74	433	131	288	P. L. Johnson	Mound
NSD-78	3-09-74	429	130	285	P. L. Johnson	Mound

Table 4.1. (continued)

Source	Date of calibration	^{252}Cf content at calibration (μg)	Content as of 9/30/78 ^{252}Cf (μg)	Content as of 9/30/78 ^{248}Cm (μg)	On loan to: Individual	On loan to: Site
NS-79	10-02-74	1,650	579	1,021	V. Spiegel	NBS
NSD-80	6-03-74	5,966	1,921	3,857	C. J. Emert	BAPL
NSD-81	6-03-74	6,364	2,049	4,115	C. J. Emert	BAPL
NS-82	5-19-75	14,264	5,904	7,973	G. Tessler	BAPL
NS-83	9-24-75	11,783	5,346	6,139	G. Tessler	BAPL
NS-84	9-30-75	12,674	5,775	6,579	G. Tessler	BAPL
NS-85	10-22-75	12,181	5,638	6,239	G. Tessler	BAPL
NS-86	11-17-75	2,620	1,236	1,320	V. Spiegel	NBS
NSD-87	10-15-75	22,387	10,311	11,516	G. I. Gleason	ORAU
NSD-88	8-28-75	9,528	4,240	5,043	R. L. Ullrich	ORNL
NSD-89	4-23-75	12,599	5,118	7,134	R. Struss	Ames Research Laboratory
NZS-90	1-16-75	0.87	<1	b	J. R. Smith	ANC
NSD-91	9-26-75	15	7	b	L. J. Esch	KAPL
NS-92	6-24-76	2,960	1,634	1,264	V. Spiegel	NBS
NSD-93	1-29-74	500	147	336	J. P. Balagna	LASL
NSD-94	3-09-77	1,544	1,026	494	F. M. Clikeman	Purdue
NSD-95	3-09-77	1,537	1,021	492	F. M. Clikeman	Purdue
NSD-96	3-09-77	1,194	793	382	F. M. Clikeman	Purdue
NSD-97	3-09-77	1,399	930	448	F. M. Clikeman	Purdue
NSD-98	9-30-75	8,000	3,645	4,153	J. L. Fuller	HEDL
NSD-99	9-21-77	715	547	160	C. A. Strand	HEDL
NSD-101	5-24-76	24,136	13,035	10,587	J. E. Powell	Sandia-New Mexico
SR-Cf-167[f]	5-26-71	3,975	580	3,238	J. E. Rushton	ORNL

[a]This source is encapsulated in aluminum.

[b]This source is not suitable for recovery of ^{248}Cm.

[c]This source is held at ORNL and is available for reissue.

[d]This source is encapsulated in Type-405 stainless steel.

[e]This source has an inner capsule of Type-405 stainless steel and an outer capsule of Type-304L stainless steel.

[f]This source was fabricated at TRU in standard Savannah River SR-Cf-100 series hardware.

5. SPECIAL PROJECTS

The primary functions of TRU are (1) to fabricate targets for irradiation in the HFIR to produce transuranium elements and (2) to isolate and purify transuranium elements for use by research workers. However, the facilities that are available[6] are also used for a variety of other purposes, such as nonroutine production, special preparations, and special irradiations in HFIR. In each case, a unique service can be provided to assist a research program at ORNL or another site.

5.1 Purification of Americium-243

The project to prepare a multigram amount of highly purified ^{243}Am (for use in neutron cross-section studies, for capture gamma studies, and as an analytical standard) was completed during this report period.[1] Ion exchange techniques were used to reduce the concentration of ^{244}Cm in the ^{243}Am to less than 1 ppm. Approximately 32 g of ^{243}Am was purified and then converted to the oxide form by calcining the oxalate. Another batch, containing 2 g of ^{243}Am, was purified further using new equipment and special care to prevent recontamination; this product contained ≤25 ppb of ^{244}Cm.

5.2 Enrichment of Plutonium-244

A project to enrich the ^{244}Pu concentration in approximately 100 mg of plutonium for use in biomedical studies was completed during this report period. During April 1977, the plutonium was irradiated in the HFIR to burn out the lighter isotopes; it was then chemically processed to isolate the irradiated plutonium.[3] The isolated plutonium was stored to await decay of ^{246}Pu (half-life = 10.85 d). A final purification run (nitrate anion exchange) was made during this report period. The final product, containing 54.3 mg of ^{244}Pu, read only 2 mR/hr at contact. The specific alpha activity of the product was about three times that of pure ^{244}Pu but only 1/1200 of that of pure ^{239}Pu; most of the excess activity came from the ^{242}Pu, which was present in a concentration of 0.6%. The complete

isotopic analysis is shown in Table 5.1, along with contributions to alpha activity.

Table 5.1. Isotopic analysis of enriched plutonium-244

Nuclide	Atom %	Percentage of alpha
^{238}Pu	0.000033[a]	11.11
^{239}Pu	0.0021[a]	2.60
^{240}Pu	0.0016	7.20
^{241}Pu	0.0013	0.07
^{242}Pu	0.572	43.62
^{244}Pu	99.423	35.40

[a]Values adjusted to agree with observed alpha pulse-height analysis.

5.3 Production of Californium-254

Californium-254 was produced by the electron-capture decay (0.078% branching) of 39-hr ^{254m}Es. The ^{254m}Es was produced by irradiation of 14 μg of isotopically pure ^{253}Es for 40 hr in a hydraulic rabbit facility of the HFIR. When ^{254}Cf is produced in this manner, it is sufficiently enhanced with respect to ^{252}Cf to permit studies of the spontaneous fission properties of ^{254}Cf without interference from the fissions of ^{252}Cf.

The irradiated rabbit (cooled for 8 hr) was transferred to TRU Cave B by means of the hydraulic transfer system from the HFIR basin. The rabbit was dissolved and chemically processed, in a manner similar to previous operations,[7] to isolate the $^{253-254m}Es$ from other actinide, fission product, and activation product elements. A high-pressure ion exchange run was made to separate the einsteinium from the initial californium daughters. Then, after a five-day interval, a second high-pressure ion exchange run was made to separate the newly ingrown californium. Product from the second run is the premium ^{254}Cf; however, the product from the first run was also of suitable quality. The isotopic compositions of the californium products are listed in Table 5.2. The assay of 0.0914 atom % ^{254}Cf in the product

Table 5.2. Californium-254 product compositions

Nuclide	First run fraction		Second run fraction	
	Atom %[a]	Percentage of fissions	Atom %[a]	Percentage of fissions
^{249}Cf	7.2	5×10^{-8}	≤2.4	∿0
^{250}Cf	86.4	2.7	∿99.91	1.10
^{251}Cf	3.6	∿0	≤3.2	∿0
^{252}Cf	2.8	16.7	≤0.91	≤1.9
^{254}Cf	0.0263[b]	80.6	0.0914[b]	98.9
Amount of ^{254}Cf shipped:	237 pg		181 pg	

[a]Deduced from alpha pulse-height analysis.

[b]Deduced from gross neutron counts with known corrections.

from the second run (determined from gross neutron counting using the published value of 3.9 neutrons released per ^{254}Cf fission) exceeds the literature value of 0.078% for the fraction of ^{254}Es which decays by electron capture to ^{254}Cf. The only californium isotopes detected by alpha pulse-height analysis were ^{250}Cf and ^{254}Cf. Values for ^{249}Cf, ^{251}Cf, and ^{252}Cf are limits of detection.

6. DECAY AND NEUTRON CROSS-SECTION DATA

The values that we are currently using for transuranium element decay data and for cross-section data in planning irradiation-processing cycles, calculating production forecasts, and assaying products are tabulated in the appendix of ORNL-5415.[1]

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