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Pu-238 PRODUCTION AT THE SAVANNAH RIVER PLANT

by

Paul L. Roggenkamp
E. I. du Pont de Nemours and Company
Savannah River Laboratory
Aiken, SC 29808

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A summary of a paper proposed for presentation at the
ANS 1987 Winter Meeting
Los Angeles, CA
November 15-19, 1987

and for publication in the transactions

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PRODUCTION OF Pu-238 AT THE SAVANNAH RIVER PLANT

Paul L. Roggenkamp, Senior Consultant
E. I. du Pont de Nemours and Company, Inc.

Capability exists at the Savannah River Plant (SRP) of the Department of Energy to produce about 50 kg of Pu-238 annually for use as the source of heat for radioisotope powered electric generators. The factor that limits the Pu-238 production is the availability of Np-237 which is the target nuclide in which neutrons are captured to produce Pu-238 by the subsequent decay of the Np-238 neutron capture product. Capacities of processing facilities at SRP match the 50 kg/yr with varying margins up to 50 percent.

Pu-238 is being considered as the heat source for electric power generation for the Boost Surveillance and Tracking System for the Strategic Defense Initiative. The Pu-238 heat source would be coupled with a dynamic energy conversion system.

The SRP reactors are ideal reactors for isotope production. The heavy water moderator provides excellent neutron economy. Reactor fuel is highly enriched uranium contained in tubular elements which are separate from the target elements whether the product be Pu-238, Pu-239, tritium or other nuclide species. The use of fuel and target elements that are separate generally simplifies the isotope recovery process. Over the years a great variety of isotopes have been produced.

For the production of Pu-238, the target nuclide is Np-237. To manufacture the neptunium targets, NpO_2 powder is compacted with aluminum powder to form a billet core which is assembled with aluminum components into a composite billet. The composite billet is extruded into a target tube having the NpO_2 -Al cermet core and aluminum cladding. The target tube is irradiated in the production reactor lattice where it displaces one of the depleted uranium target assemblies used for Pu-239 production. Up to one-fourth of the depleted uranium target assemblies may be replaced at any one time. During irradiation to produce specification plutonium at about 83% Pu-238, about 25% of the Np-237 is transmuted by neutron capture with about 16% remaining as Pu-238. The 9% difference is in higher mass plutonium isotopes and fission products.

The Pu-238 product is recovered from the Np-237 targets chemically (Ref. 1). After cooling, the targets are dissolved in nitric acid in a special section of the chemical reprocessing canyon. The plutonium, neptunium, and fission products and aluminum are partitioned by ion exchange techniques. In a facility with manipulator handling capability, the plutonium and neptunium nitrates are converted to oxides. The neptunium is recycled to target assemblies and the plutonium is sent to the heat source fabrication facility where it is formed into spheres each containing a nominal 112 grams of Pu-238, the spheres are then enclosed within an iridium shell.

The Np-237 feed material is produced gratuitously in the course of making the Pu-239 and tritium major products of SRP. The primary source of Np-237 is the enriched uranium fuel which is recycled for economic reasons. About 16% of neutron absorptions in U-235 result in the formation of U-236, which upon uranium recycle accompanies the U-235 back into the reactor. The U-237 that results from neutron capture in U-236 decays to Np-237. A secondary source results from an (n,2n) reaction on the U-238 target material for Pu-239 production. The Np-237 is recovered during reprocessing of both the enriched uranium fuel and the depleted uranium targets.

The current inventory of Np-237 is about 400 kg, which with the annual production rate of Np-237 of about 80 kg, will sustain an annual Pu-238 production rate of about 50 kg. The unit cost of the Pu-238 is about \$1200 per gram for manufacture and about \$400 per gram for heat source fabrication exclusive of the cost of the iridium shell material.

1. G. A. Burney, Pu-238 Processing at Savannah River Plant, ANS Transactions 45, 247 (1983).

The information contained in this article was developed during the course of work under Contract No. DE-AC09-76SR00001 with the U.S. Department of Energy.

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E. I. DU PONT DE NEMOURS & COMPANY
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ATOMIC ENERGY DIVISION

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA 29808-0001
(TWX: 810-771-2670, TEL: 803-725-6211, WU: AUGUSTA, GA.)

June 2, 1987

Mr. M. R. Grant, Tech Program Chairman
Attn: Transactions Office
American Nuclear Society
555 North Kensington Avenue
La Grange Park, IL 60525

Dear Mr. Grant:

Four copies of the summary of the paper "Pu-238 Production at the Savannah River Plant" (DP-MS-87-54X) by P. L. Roggenkamp are enclosed. This is an invited paper for the ANS 1987 Winter Meeting in Los Angeles in November. The Summary Cover and Filing and Mailing Information Sheets (pages 2 and 3) are also enclosed.

If we can be of further assistance, please let me know.

Very truly yours,

L. W. Ice
Publications Division

LWI:twv

Enclosures

BCC: P. L. Roggenkamp, 773-41A
T. C. Sutherland, 773-A
SRL File: (DP-MS-87-54X), 773-A ←

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AIKEN, SOUTH CAROLINA 29808-0001
(TWX: 810-771-2670, TEL: 803-725-6211, WU: AUGUSTA, GA.)

June 12, 1987

Ms. Joann Hollensteiner
ANS Transactions Coordinator
American Nuclear Society
555 North Kensington Avenue
La Grange Park, IL 60525

Dear Ms. Hollensteiner:

Attached are the original and three copies of a revised version of the Summary, Pu-238 Production at the Savannah River Plant (DP-MS-87-54X, revised) by P. L. Roggenkamp, your Log #27. Please replace the initial version of the summary with the revised version.

If we can be of further assistance, please let me know.

Yours very truly,

L. W. Ice
Publications Division

LWI:tww

Enclosures

BCC: P. L. Roggenkamp, 773-41A
T. C. Sutherland, 773-A

SRL File: (DP-MS-87-54X), 773-A

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MANUSCRIPT APPROVAL

Route in turn to

Initials Date

Initials Date

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2. SUPERVISOR

3. DIVISION HEAD/DEPARTMENT
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4. PD EDITOR

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Circle one for each

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S C ☒APPROVAL: DLR
DLR 5/1/87
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 Department Superintendent

PD

CLASSIFICATION
GUIDE TOPICSSR-1C-50Topic 292-11

PATENT CONSIDERATIONS

POSSIBLE NOVEL FEATURES NA

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CITY Los Angeles, CADATES Nov. 15-19, 1987

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(TWX: 810-771-2670, TEL: 803-725-6211, WU: AUGUSTA, GA.)

CC: W. F. Perrin, DOE-SR (2)
M. F. Sujka, 703-A
J. F. Ortaldo, 703-A
L. W. Ice, 703-43A
J. M. Boswell-P. L. Roggenkamp, 773-41A
File (DP-MS-87-54X)

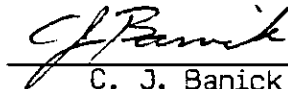
May 6, 1987

Mr. J. R. Powell, Technical Information Officer
U. S. Department of Energy
Savannah River Operations Office
Aiken, SC 29801

Dear Mr. Powell:

REQUEST FOR APPROVAL TO RELEASE SCIENTIFIC/TECHNICAL INFORMATION

The attached document is submitted for your approval for external release. Please complete Part II of this letter and return the letter to the undersigned, by: ASAP 6/19/87. Patent clearance is requested and received via direct communication between DOE Patent Counsel and AED Patent Reviewer. The document has ~~not~~ been reviewed for classification and UCNI. The document is ~~classified~~/unclassified and contains no UCNI. (Strike words that do not apply.)


C. J. Banick

AED Classification Officer

I. DETAILS OF REQUEST FOR RELEASE

DP-MS-87-54X, "PU-238 PRODUCTION AT THE SAVANNAH RIVER PLANT", By P. L. Roggenkamp

A summary of a paper proposed for presentation at the ANS 1987 Winter Meeting in Los Angeles, CA., on November 15-19, 1987.

Technical questions pertaining to the contents of this document should be addressed to the author(s) or

P. L. Roggenkamp, Senior Consultant
Operational Planning
Savannah River Laboratory

Questions concerning processing of this document should be addressed to the AED Classification Officer & Patent Reviewer at Extension 52606.

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_____, Date _____
J. R. Powell, Technical Information Officer, DOE-SR

May 6, 1987

TO: J. F. SABINO

FROM: C. J. BANICK *CJB*

DOCUMENT REVIEW

Document(s): DP-MS-87-54X

Title(s): "PU-238 PRODUCTION AT THE SAVANNAH RIVER PLANT"

Author(s): P. L. Roggenkamp

Contractual Origin: DE-AC09-76SR00001

Present Classification: Unclassified Paper

References:

No items were noted that, in my opinion, should be called to the attention of the DOE for patent consideration.



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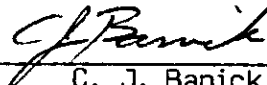
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J. R. Powell, Technical Information Officer, DOE-SR, Date 5/27/87



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(TWX: 810-771-2670, TEL: 803-725-6211, WU: AUGUSTA, GA.)

May 6, 1987

Mr. A. F. Westerdahl, Chief
Patent Branch
U. S. Department of Energy
Aiken, South Carolina 29808

Dear Mr. Westerdahl:

REQUEST FOR PATENT REVIEW

Please review for patent matters:

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Please telephone your comments to the Records Management Office (Ext. 52606) and notify me by signing and returning to C. J. Banick the original of this letter. A copy is provided for your file.

If you decide to pursue a patent on any development covered, I shall be happy to supply additional information required such as appropriate reference and the names of persons responsible for the development.

Very truly yours,

C. J. Banick,
AED Patent Reviewer

The above item is approved for release

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 AUTHOR(S)
 P. L. Roggenkamp

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C. J. Banick C.J. Banick 5/5/87
 (AED CLASSIFICATION OFFICER) DATE

Authority for Classification Determination SR-1C-50, Topic 292.11
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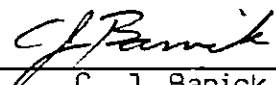
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For the production of Pu-238, the target nuclide is Np-237. To manufacture the neptunium targets, NpO_2 ~~oxide~~ is compacted with aluminum powder to form a billet core which is assembled with aluminum components into a composite billet. The composite billet is extruded into a target tube having the NpO_2 -Al cermet core and aluminum cladding. The target tube is irradiated in the production reactor lattice where it displaces one of the depleted uranium target assemblies used for Pu-239 production. Up to one-fourth of the depleted uranium target assemblies may be replaced at any one time. During irradiation to produce specification plutonium at about 83% Pu-238, about 25% of the Np-237 is transmuted by neutron capture with about 16% remaining as Pu-238. The 9% difference is in higher mass plutonium isotopes and fission products.

The Pu-238 product is recovered from the Np-237 targets chemically (Ref. 1). After cooling, the targets are dissolved in nitric acid in a special section of the chemical reprocessing canyon. The plutonium, neptunium, and fission products and aluminum are partitioned by ion exchange techniques. In a facility with manipulator handling capability, the plutonium and neptunium nitrates are converted to oxides. The neptunium is recycled to target assemblies and the plutonium is sent to the heat source fabrication facility where it is formed into spheres each containing a nominal 112 grams of Pu-238, the spheres are then enclosed within an iridium shell.

The Np-237 feed material is produced gratuitously in the course of making the Pu-239 and tritium major products of SRP. The primary source of Np-237 is the enriched uranium fuel which is recycled for economic reasons. About 16% of neutron absorptions in U-235 result in the formation of U-236, which upon uranium recycle accompanies the U-235 back into the reactor. The U-237 that results from neutron capture in U-236 decays to Np-237. A secondary source results from an (n,2n) reaction on the U-238 target material for Pu-239 production. The Np-237 is recovered during reprocessing of both the enriched uranium fuel and the depleted uranium targets.

The current inventory of Np-237 is about 400 kg, which with the annual production rate of Np-237 of about 80 kg, will sustain an annual Pu-238 production rate of about 50 kg. The unit cost of the Pu-238 is about \$1200 per gram for manufacture and about \$400 per gram for heat source fabrication exclusive of the cost of the iridium shell material.

-
1. G. A. Burney, Pu-238 Processing at Savannah River Plant, ANS Transactions 45, 247 (1983).

The information contained in this article was developed during the course of work under Contract No. DE-AC09-76SR00001 with the U.S. Department of Energy.



E. I. DU PONT DE NEMOURS & COMPANY
INCORPORATED

ATOMIC ENERGY DIVISION

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA 29808-0001

(TWX: 810-771-2670, TEL: 803-725-6211, WU: AUGUSTA, GA.)

CC: W. F. Perrin, DOE-SR (2)
M. F. Sujka, 703-A
J. F. Ortaldo, 703-A
L. W. Ice, 703-43A
P. L. Roggenkamp, 773-41A
File: (DP-MS-87-54)


September 30, 1987

Mr. J. R. Powell, Technical Information Officer
U. S. Department of Energy
Savannah River Operations Office
Aiken, SC 29801

Dear Mr. Powell:

REQUEST FOR APPROVAL TO RELEASE SCIENTIFIC/TECHNICAL INFORMATION

The attached document is submitted for approval for external release. Please complete Part II of this letter and return the letter to the undersigned, by: 10/14/87 Patent clearance is requested and received via direct communication between DOE Patent Counsel and AED Patent Reviewer. The document has ~~not~~ been reviewed for classification and UCNI. The document is ~~classified~~ unclassified and contains no UCNI. (Strike words that do not apply.)


C. J. Banick AED Classification Officer

I. DETAILS OF REQUEST FOR RELEASE

DP-MS-87-54, "PU-238 PRODUCTION AT THE SAVANNAH RIVER PLANT", By P. L. Roggenkamp.

A paper proposed for presentation at the ANS 1987 Winter Meeting in Los Angeles, CA., on November 15-19, 1987.

Technical questions pertaining to the contents of the document should be addressed to the author(s) or

P. L. Roggenkamp, Senior Consultant
Operational Planning
Savannah River Laboratory

Questions concerning processing of this document should be addressed to the AED Classification Officer & Patent Reviewer at Extension 5-2606.

II. DOE-SR ACTION

DATE RECEIVED BY TIO 10-5-87

☒ Approved as written
☐ Remarks

☐ Not approved as written, ☐ revise and resubmit to DOE
☐ Approved upon completion of changes marked on document


J. R. Powell, Technical Information Officer, DOE-SR

Date 10/14/87

SAVANNAH RIVER
DOCUMENT APPROVAL SHEET
(See SRP Procedures Manual Item 101)Document Number DP-MS-8754
UC or C Number _____

1. DESCRIPTION OF DOCUMENT (to be completed by author)

TITLE Pu-238 Production at the Savannah River PlantAUTHOR(S) Paul L. RoggenkampPHONE NO. 5-5320TYPE: ☐ INTERNAL DOCUMENT☐ EXTERNAL DOCUMENT☐ DP Report☒ Paper (see below)☐ Other _____

Additional Information for External Papers

PAPER FOR: Presentation Only ☒ * _____

Publication Only _____

Both _____

MEETING NAME ANS Winter MeetingCITY Los Angeles, CADATES Nov. 15-19, 1987CHAIRMAN & ADDRESS Norbert R. Grant, ANS, 555 N. Kensington Ave., LaGrange Park, IL 60525JOURNAL NAME ---

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CLASSIFICATION GUIDE TOPICS

SR-IC-50Topic 292.11.1292.12.5

PATENT CONSIDERATIONS

Possible Novel Features _____

Closest Prior Art _____

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AUTHOR(S) Paul L. Roggenkamp 773-41ATITLE Pu-238 Production at the Savannah River PlantDIVISION Operational Planning

MANUSCRIPT APPROVAL

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Initials Date

Initials Date

1. AUTHOR

DLR 9/25

6. AUTHOR

2. SUPERVISOR

7. DIVISION HEAD/DEPARTMENT
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DLR 9/28/87
 Division Head/
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GUIDE TOPICSSR-4C-50292.11.1292.12.5

PATENT CONSIDERATIONS

POSSIBLE NOVEL FEATURES None

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L. W. Ice 703-43A
P. L. Roggenkamp, SR 2 703-41A
File (DP-MS-87-54)

~~To Ortaldo~~
To Powell:

P.L. Roggenkamp, Senior Consultant
Operational Planning
ERL Laboratory

OSR 14 357 is on the way

no others needed



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INCORPORATED

ATOMIC ENERGY DIVISION

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA 29808-0001
(TWX: 810-771-2670, TEL: 803-725-6211, WU: AUGUSTA, GA.)

July 20, 1987

Mr. A. F. Westerdahl, Chief
Patent Branch
U. S. Department of Energy
Aiken, South Carolina 29808

Dear Mr. Westerdahl:

REQUEST FOR PATENT REVIEW

Please review for patent matters:

DP-MS-87-54, "AGENCY UPDATE", By B. J. Eberhard.

A paper proposed for publication only from the IMOG Joining Committee Meeting held at Rocky Flats on March 10-12, 1987.

Please telephone your comments to the Records Management Office (Ext. 52606) and notify me by signing and returning to C. J. Banick the original of this letter. A copy is provided for your file.

If you decide to pursue a patent on any development covered, I shall be happy to supply additional information required such as appropriate reference and the names of persons responsible for the development.

Very truly yours,

C. J. Banick

C. J. Banick,
AED Patent Reviewer

The above item is approved for release

A. F. Westerdahl
A. F. Westerdahl
Chief Patent Branch
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7/27/87
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DOCUMENT NO. DP-MS-86-54

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DP REPORT ☐- PAPER ☒

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WORKS TECHNICAL STANDARD
PRACTICE MANUAL, BULLETIN 7-2

DATE

3/10/87

2784

TITLE OF PAPER

AGENCY UPDATE

AUTHOR(S)

B. J. EISENHARD

DEPARTMENT

SRL/RED

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ARTICLE☐ YES ☒ NO

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FOR INCLUSION IN THE MINUTES OF SPRING 1987 MEETING
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DATE

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CG-DAR-1, Topic 1.1

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July 20, 1987

TO: J. F. SABINO

FROM: *J. H. Conover for*
C. J. BANICK

DOCUMENT REVIEW

Document(s): DP-MS-87-54

Title(s): "AGENCY UPDATE"

Author(s): B. J. Eberhard

Contractual Origin: DE-AC09-76SR00001

Present Classification: Unclassified Paper

References:

No items were noted that, in my opinion, should be called to the attention of the DOE for patent consideration.