**Cover Sheet for a Hanford
Historical Document
Released for Public Availability**

Released 1995

**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute**

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

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, make 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.

DECLASSIFIED

DOCUMENT NO.

HW-31952

HANFORD TECHNICAL RECORD
GENERAL ELECTRIC

HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

DATE

5-28-54

COPY NO. AND SERIES

2

☒

RESTRICTED DATA

THIS DOCUMENT CONTAINS RESTRICTED DATA
DEFINED BY THE ATOMIC ENERGY ACT OF 1954.
IT IS PROHIBITED TO TRANSMIT OR DISCLOSE ITS
CONTENTS IN ANY MANNER TO AN UNAUTHORIZED
PERSON IS PROHIBITED.

FILE DESIGNATION

300 N

TITLE

Plutonium Product Quality

AUTHOR

R. O. Gumprecht

THIS DOCUMENT MUST NOT BE LEFT UNATTENDED OR WHEN AN UNAUTHORIZED PERSON MAY HAVE ACCESS
TO IT. WHEN NOT IN USE IT MUST BE STORED IN AN APPROVED LOCKED REPOSITORY WITH AN APPROVED
GUARDED AREA. IF IT IS IN YOUR POSSESSION UNTIL YOU HAVE OBTAINED A RECEIPT FROM
CLASSIFIED AREA, IT IS YOUR RESPONSIBILITY TO KEEP IT AND ITS CONTENTS WITHIN THE LIMITS
THIS PROHIBITION AND FROM ANY UNAUTHORIZED PERSON, ITS TRANSMITTAL OR STORAGE AT YOUR
OF ACCESS IS PROHIBITED. IT IS TO BE DUPLICATED. ORIGINAL COPIES ARE REQUIRED,
THEM FROM THE RELATIVE FILE. ALL PERSONS WHO USE THIS DOCUMENT ARE REQUESTED
SIGN IN THE SPACE PROVIDED BELOW.

ROUTE TO:

READ BY:

DATE

ROUTE TO:

READ BY:

DATE

RECORD
COPY

MASTER

Indefinite Retention

Disposal Date

Authority

Authority

DECLASSIFIED

~~RESTRICTED DATA~~
This document contains ~~RESTRICTED DATA~~ as defined in the Atomic Energy Act of 1954. Its transmission or the disclosure of its contents to an unauthorized person is prohibited.

CLASSIFICATION CANCELLED AND CHANGED TO

DECLASSIFIED

BY AUTHORITY OF CG-PR-2

RM Hen 10-21-92

BY J E Savely 10-21-92

VERIFIED BY JK BORUSDE 10-26-92

NOT UCN!

1. R.L. Dickeman
2. G.C. Fullmer
3. R.O. Gumprecht
4. H.L. Henry -- H. G. Spencer
5. O.H. Hill - A.E. Smith
6. E.M. Kinderman
7. L.M. Knights
8. C.B. McKee
9. J.A. Merrill - F.H. Tingey
10. S.L. Nelson
11. E.T. O'Sullivan
12. W.J. Ozeroff - B.R. Leonard - J.O. Erkman
13. P.H. Reinker
14. R.B. Richards
15. C.J. Shortess
16. W.K. Woods
17. 300 Copy
18. Yellow Copy

May 28, 1954

This document consists of
3 pages. Copy 2 of
18 copies. Series

H. L. Henry
Supervisor, Process Technology Sub-Unit
Technical Section
ENGINEERING DEPARTMENT

PLUTONIUM PRODUCT QUALITY

INTRODUCTION

Equations relating product buildup and product quality to exposure in the present Hanford reactors are given in HW-31295⁽¹⁾ as follows:

$$\text{Grams Pu/ton} = 0.974 \text{ M e}^{-(2.15\text{M} \times 10^{-4})}$$

$$\% \text{ Pu}^{240} \text{ in Product} = 0.00908 \text{ M e}^{-(2.68\text{M} \times 10^{-4})}$$

Where: M = Metal Exposure in MWD/ton

Since the weight of Pu 240 per ton of exposed metal is approximately proportional to the square of the exposure and the amount of product per ton is approximately proportional to the first power of the exposure, the ordinary arithmetic average exposure of a blended discharge cannot be used to correctly predict the quality of the product extracted from low exposure uranium. Thus, one ton of metal exposed to 300 MWD/ton blended with one ton of metal exposed to 100 MWD/ton will contain about 12 per cent more Pu 240 than two tons of metal exposed to 200 MWD/ton. Obviously, as the range of blending is varied the product quality will also vary for a given average metal exposure. Therefore, a tube by tube calculation should be carried out to insure that the Hanford products will meet the isotopic

(1) HW-31295, "Recommended Factors for Predicting Plutonium Yield and Quality", R. B. Richards, April 2, 1954.

MASTER

purity specifications given by the Atomic Energy Commission; (2) these specifications place limits on the acceptable spontaneous fission rates of the products in terms of neutrons emitted per gram of plutonium per second (n/g-s). The n/g-s value of low exposure product shall not exceed 20. The n/g-s value of all other product shall not exceed 80.

SUMMARY

It is recommended that the average tube exposure of a blended low exposure shipment should not exceed 28 MWD where the average tube exposure is defined as follows:

$$M_{av} = \frac{\sum M^2}{\sum M}$$

Where: M = Individual tube exposure in MWD
 $\sum$ = Summation over all tubes included in the shipment.

For all other shipments the ordinary arithmetic average tube exposure should not exceed 140 MWD in order to stay under the 80 n/g-s limit.

BASIS

The equations relating product buildup and product quality to exposure in the present Hanford reactors given in HW-31295 can be expressed in terms of tube exposure as follows:

$$\text{Grams Pu/tube} = 0.974 M e^{-(1.70M \times 10^{-3})} \quad (1)$$

$$\% \text{ Pu}^{240} \text{ in Product} = 0.0716 M e^{-(2.11M \times 10^{-3})} \quad (2)$$

Where: M = Tube exposure in MWD

For a blended shipment consisting of metal discharged from various tubes at various exposures the per cent Pu 240 in the product is given by the following equation which is obtained directly from equations (1) and (2):

$$\% \text{ Pu}^{240} \text{ in Product} = 0.0716 \frac{\sum M^2 e^{-(3.81M \times 10^{-3})}}{\sum M e^{-(1.70M \times 10^{-3})}} \quad (3)$$

Where: $\sum$ signifies a summation over all the tubes included in the shipment.

For low exposures the exponentials included in the above equations are very slowly varying functions of the tube exposure. Consequently, a good approximation of equation (3) is obtained by factoring out the exponentials leaving:

$$\% \text{ Pu}^{240} \text{ in Product} = 0.0716 e^{-(2.11M_{av} \times 10^{-3})} \frac{\sum M^2}{\sum M} \quad (4)$$

This result shows that equation (2) which is applicable to single tubes can be used in place of the more cumbersome equation (3) for blended discharges provided

(2) HAN-54469, "Isotopic Purity Specifications", D. G. Sturges to A. B. Greninger, April 8, 1954.

the average tube exposure given by $\Sigma M^2 / \Sigma M$ is used.

Analysis of reactor discharges during 1953 shows that for exposure of 600 MWD/ton (76.1 MWD/tube), or higher, the average tube exposure given by $\Sigma M^2 / \Sigma M$ is only about one percent higher than the ordinary arithmetic average tube exposure. For exposures of 200 MWD/ton the average tube exposure given by $\Sigma M^2 / \Sigma M$ is likely to be from five to ten per cent higher than the arithmetic average. Consequently, a calculation of $\Sigma M^2 / \Sigma M$ is needed only for low exposure shipments. For high exposure shipments calculation of the ordinary arithmetic average tube exposure is sufficient under the current spread in tube discharge concentrations.

It has been shown⁽³⁾ that the neutron emission rate of plutonium is directly proportional to the per cent Pu 240 present. Consequently, the equations relating per cent Pu 240 to tube exposure may be converted to give the n/g-s value by a simple conversion factor.⁽²⁾ Since Hanford's present best n/g-s value for 600 MWD/ton plutonium is 49.8,⁽⁴⁾ the following relationship is obtained from equation (2):

$$\text{n/g-s of Product} = 0.76 M_{av} e^{-(2.11 M_{av} \times 10^{-3})}$$

Here again, M_{av} refers to the average tube MWD defined by $\Sigma M^2 / \Sigma M$ for a blended discharge of low exposure material.

Simple substitution in the above equation shows that M_{ave} for the 20 n/g-s product should not exceed 28 MWD/tube and M_{ave} for the 80 n/g-s product should not exceed 140 MWD/tube. These exposures correspond to 220 and 1100 MWD/ton respectively. The ordinary average exposure for the 20 n/g-s product will probably run about 210 MWD/ton for the present range of blending.

DISCUSSION

In the equations used here no attempt has been made to correct for variations in the Pu 240 yield due to capture or lack of capture of neutrons by Np 239 since no cross section data for Np 239 are presently available;⁽⁵⁾ ⁽⁶⁾ Assuming that the Pu 240/Pu 239 ratio at a given exposure is independent of specific power has the same effect as assuming that the capture cross section of Np 239 is approximately the same as that of Pu 239. It is understood that plans are currently being made to perform experiments to measure the neutron capture cross section of Np 239. Depending on the outcome of these experiments and depending on the results obtained by routine tests of the quality of the final product, it may be necessary at some time in the future to revise the exposure estimates presented here.

Pile Physics Sub-Unit
Technical Section
ENGINEERING DEPARTMENT

RO GUMPRECHT:rt

- (3) LA-1582, "Isotopic Analyses of Hanford, Chalk River, and Clinton Plutonium Samples", W. W. Carter, July 8, 1953.
- (4) HW-3495-T, A. E. Smith, Secret Notebook.
- (5) HW-31016, "The Dependence of Pu 240 Concentration in Pile-Produced Plutonium on Neutron Flux Level", B. R. Leonard Jr., 3-3-54.
- (6) HW-31431, "Variation of Exposure of Low G/T Material Due to the Dependency of Pu 240 Concentration on Tube Power", J. O. Erkman, 4-12-54.