

Neutron Dose Assignment for Plutonium Fuel at W.R. Grace

White Paper

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INTRODUCTION

Plutonium fuel production at W.R. Grace took place during the period of 1965 to 1972, primarily in Buildings 234 and 110. During the period from 1973 to 1987, the facilities were placed in a safe standby mode, followed by a decontamination mission that took place between 1987 and 1994 (Haskins 2007). At this time, the Exposure Matrix for W.R. Grace has limited information regarding the assignment of potential neutron dose from this source term during this period. Neutron dosimetry data from employees is sporadic – only 15 claims with potential neutron data have been identified, and, of these, none contained information from the plutonium fuel production period. In addition, no survey data has been located that could be used to develop a neutron-to-photon (N:P) ratio (ORAUT 2011).

PURPOSE

The purpose of this white paper is to determine a reasonable N:P ratio that can be used to assign neutron dose for W.R. Grace energy employees who worked in the plutonium fuel fabrication process during periods when neutron dose data was not reliable, not available, or not recorded.

BACKGROUND

The production locations for plutonium fuel fabrication are given in Table 2-1 of the W.R. Grace Exposure Matrix (ORAUT 2011). The timeline of production, and decontamination and decommissioning (D&D) activities is given above.

MOX Fuel Production Process and Composition

The majority of the plutonium used in the mixed oxide (MOX) fuel production process was received from the Hanford site in the form of plutonium nitrate. Smaller amounts of plutonium were received from the West Valley and SRS sites.

The MOX fuel production process is summarized in Figure 1 (Booth 1989, p. 118) and described in detail in a letter written from R.L. Booth (NFS) to the Department of Energy Richland Operations Office in 1989. Further, a summary of the composition of the MOX fuel products is given in Table 1 (Booth 1989, p. 119).

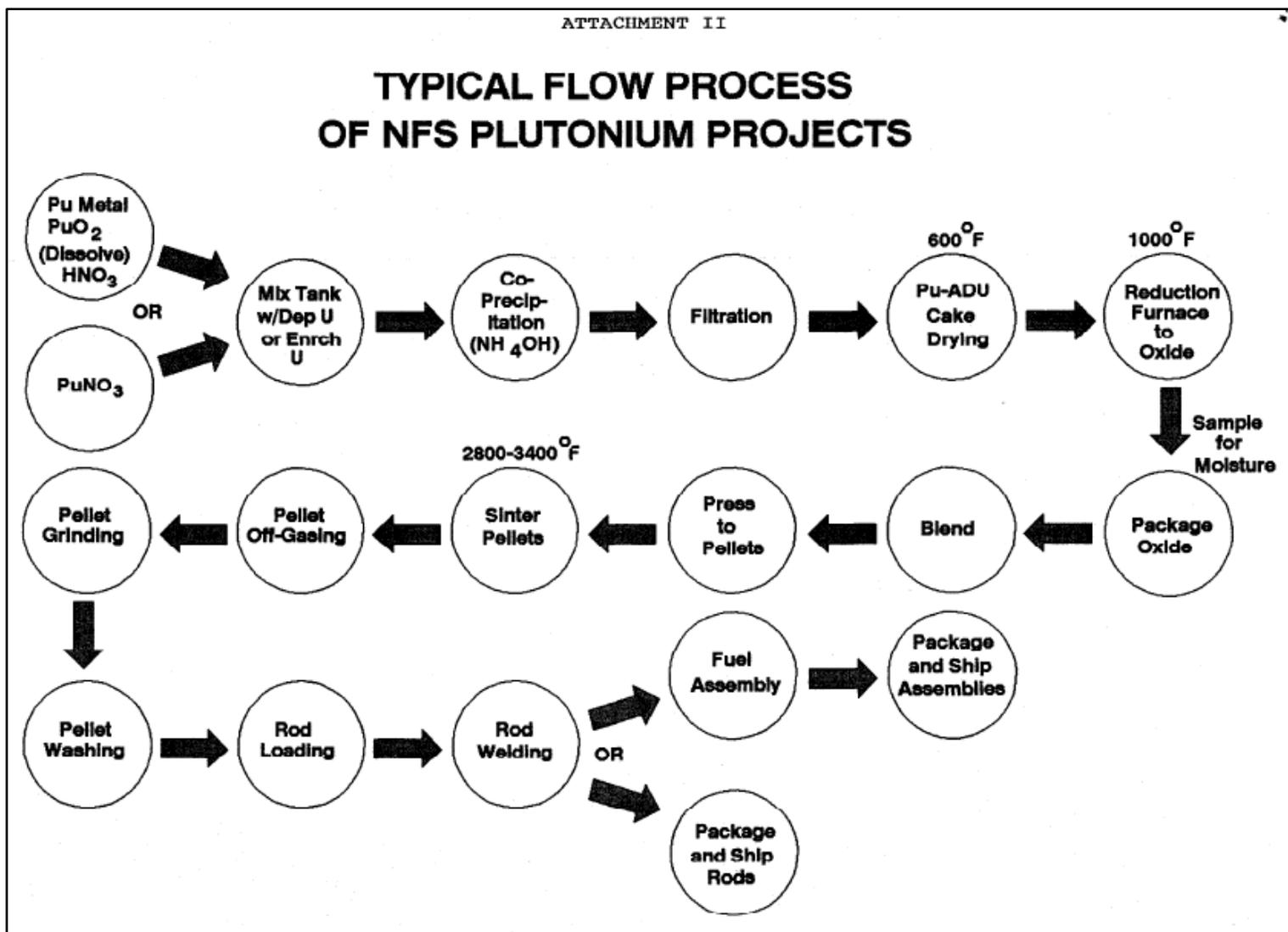


Figure 1. Typical Flow Process of NFS Plutonium Projects (Booth 1989, p. 118).

Table 1. Plutonium Sources (Booth 1989, p. 119).

ATTACHMENT III								
PLUTONIUM SOURCES								
<u>NFS S.O.</u>	<u>Date</u>	<u>Project/Customer</u>	<u>Product</u>	<u>Original Kg-Pu</u>	<u>Mixture</u>	<u>% U</u>	<u>% Pu</u>	<u>Uranium Enrichment</u>
3163	1965- 1966	DuPont/SRO (DuPont P.O. AX-2640) (AEC: AT/07/-2/1)	MOX Fuel Rods	16	Uranium	99.7	0.315	Depleted
256-A	1967- 1971	SEFOR/GE/AEC (GE P.O. 205-58226-NG) (AEC: AT/04-3/-647)	MOX; 2000 Fuel Rods and scrap dissolution	746	Uranium	80.0	20.00	Depleted
Sub-Total Government Program:				<u>762 (94%)</u>				
945-E	1972	Halden/NFS-RFD (35% of Pu from NPR Fuel)	MOX Fuel Rods	3	Uranium	98.5 to 97.5	1.5 to 2.5	Depleted and 1.0% to 5.0%
1021-F	1972- 1973	Big Rock Point (Consumers)/NFS-RFD	MOX Fuel assemblies	47	Uranium	97.53	Avg. 2.27	Avg. 2.41%
Sub-Total NFS Programs:				<u>50 (6%)</u>				
Total				<u>812 (100%)</u>				

Section 4.3 of the Exposure Matrix indicates that there are no documented neutron exposures at W.R. Grace; however, the potential for neutron dose is acknowledged due to the presence of highly-enriched uranium and plutonium materials. Due to the low potential for neutron dose, it is apparent that the site did not monitor for neutron exposure, especially during the production period (ORAUT 2011).

Since site-specific data for potential neutron dose assignment for this source term is lacking, a survey of N:P data associated with plutonium production and fuel fabrication at other sites associated with the Energy Employees Occupational Illness Compensation Program Act of 2000 (EEOICPA) was conducted.

N:P DATA SURVEY FOR PLUTONIUM PRODUCTION AND FUEL FABRICATION

Data for an N:P ratio that could be used for plutonium fuel neutron dose assignment were found in several EEOICPA program site profiles or Special Exposure Cohort (SEC) Petition ER documents. Plutonium production N:P data is available in the Hanford, Savannah River Site (SRS), and Rocky Flats Plant (RFP) external dose site profiles. Data that is more specific to the plutonium fuel production process was found in the Nuclear Materials and Equipment Corporation (NUMEC) site profile, as well as in data associated with SRS.

Plutonium Production N:P Data

Table 2 provides a summary of the N:P ratios associated with the production and handling of plutonium products.

Table 2. N:P Values for Plutonium Processing Facilities.

Site	N:P Ratio	Data Source
Hanford	GM= 1.7, GSD = 2.6 (glovebox workers) GM = 1.1, GSD = 2.3 (non-glovebox) – (For the period prior to 1972)	ORAUT 2010a
SRS	GM = 0.91, GSD = 2.84 (HB Line) GM = 0.36, GSD = 2.52 (FB Line) (For the period 1954-1970)	ORAUT 2005
RFP	GM = 0.42, GSD = 3 (For the period 1977 to 2000)	ORAUT 2010b

NUMEC Data

Table 2-3 in Section 2.2.1, and Section 2.2.3.1 of the NUMEC site profile (ORAUT 2017) describes the plutonium fuel fabrication process history at that site. These activities may serve as

a better surrogate for the work that was performed at W.R. Grace (ORAUT 2011). The NUMEC work with Fast Flux Test Facility (FFTF) MOX fuel had a similar 20:80 ratio by mass of PuO₂ to UO₂ as seen with the South-West Experimental Fast Oxide Reactor (SEFOR) fuel work at W.R. Grace cited in Table 1.

Based on data from worker dosimetry studies performed at NUMEC during work with the FFTF fuel, Section 6.5.2.4 recommends an N:P ratio of 0.34 (GSD = 1.71) for general workers and 1.00 (GSD = 1.49) for glovebox workers (ORAUT 2017).

SRS 321-M Data

N:P data were developed, but not published, based on survey data associated with the Mark 42 Pu-Al fuel production operations at 321-M at SRS (Brown 2014). The analysis of approximately 100 paired neutron and gamma survey results yields an N:P ratio of 0.21 ±0.10. A description of the process used at 321-M can be found in Section 5.3.4.2.4.2 of the SRS site profile (ORAUT 2005).

DISCUSSION

A survey of the available N:P data associated with plutonium processing and plutonium fuel fabrication yielded values ranging from 0.34 to 1.7. Because the data from the NUMEC site profile are based on worker dosimetry studies, and the work involved plutonium fuel fabrication with a composition similar to the product at W.R. Grace, the data from that site are recommended for assignment of plutonium fuel neutron dose at W.R. Grace. Specifically, the N:P ratio(s) would be defined as lognormal distributions with the following parameters:

- GM = 0.34, GSD = 1.71 (for general workers in Buildings 234 and 110), and
- GM = 1.00, GSD = 1.49 (for glovebox workers in Buildings 234 and 110).

In order to maintain consistency, assignment of photon and neutron energies should also follow the NUMEC guidance from Table 6-8 of ORAUT (2017), which is:

- Photons: 100%, 30-250 keV, and
- Neutrons: 100%, 0.1 – 2 MeV.

Guidance regarding identification of employees who performed plutonium fuel fabrication can be found in OCAS-TIB-007 *Neutron Exposures at the Savannah River Site*. In addition to any employee or survivor interview information – or site-provided information - regarding job duties, records of plutonium bioassay (if available) would be an indication of external exposure to photons and neutrons from a plutonium source term. Further, if a high shallow to deep dose ratio (> 2.0) is noted, this could be an indication of glovebox work (OCAS, 2007).

REFERENCES

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