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Advisory Board on Radiation and Worker Health
National Institute for Occupational Safety and Health

SC&A's Review of NIOSH's White Paper, "Internal Dosimetry Coworker Intake and Exposure Model for the W. R. Grace Company, Erwin, Tennessee"

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Table of Contents

Abbreviations and Acronyms

ABRWH, Board	Advisory Board on Radiation and Worker Health
AWE	Atomic Weapons Employer
CW	coworker
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
dpm/d	disintegrations per minute per day
DR	dose reconstruction
IMBA	Integrated Modules for Bioassay Analysis
m^3	cubic meter
MPC	maximum permissible concentration
µCi/mL	microcurie per milliliter
NFS	Nuclear Fuel Services
NIOSH	National Institute for Occupational Safety and Health
NOCTS	NIOSH OCAS Claims Tracking System
ORAUT	Oak Ridge Associated Universities Team
OTIB	ORAUT technical information bulletin
SEC	Special Exposure Cohort
WRG	W. R. Grace

1 Introduction and Background

W. R. Grace Company (WRG) was an Atomic Weapons Employer (AWE) facility from 1958 through 1970 with an AWE residual contamination period from 1971 through March 1, 2011. The National Institute for Occupational Safety and Health (NIOSH) issued on March 1, 2019, the white paper *Internal Dosimetry Coworker Intake and Exposure Model for the W. R. Grace Company, Erwin, Tennessee* (NIOSH, 2019; hereafter referred to as the "white paper"). The purpose of the white paper was to develop plutonium intake data from recorded coworker (CW) bioassay data and air concentration measurements to assign intake values to workers with gaps in their plutonium bioassay data or for workers that should have been monitored for plutonium.

NIOSH used recorded bioassay plutonium data from the period of 1967–1973 and gross-alpha air concentration measurements from the period of 1976–1993 to predict the potential intakes of plutonium (as Pu-239), solubility Types M and S, for the plant production period (1965–1973) and plant residual period (1974–2011) at WRG. SC&A was tasked on March 20, 2019, to review the white paper.

2 Outline of White Paper

2.1 Plutonium activities and characteristics at WRG

- Table 1, page 7, of the white paper provides a timeline and summary of the plutonium activities at WRG (1964–2009).

- Tables 2 and 3, page 8, of the white paper provide a summary of the quantities and types of plutonium processed at WRG.

- Table 4, page 10, of the white paper provides a summary of the radionuclide assumptions used to develop the CW model.

2.2 Bioassay data 1967–1973

- **Source of plutonium bioassay data** – Because no electronic database for plutonium bioassays existed at WRG, NIOSH used the plutonium bioassay data from claims in the NIOSH OCAS Claims Tracking System (NOCTS) to perform a CW intake analysis for the 1967 to 1973 period of WRG's plutonium production. The derived intake rates for 1967 were extended back to include the period of plutonium operation of January 1, 1965, through 1966.

- **Analyses of plutonium bioassay data** – Attachment B of the white paper provides instructions for how to organize and sort the bioassay data from NOCTS to determine the annual excretion rates. The recorded data were obtained from gross alpha counting of urine samples; it was assumed the radioactive material was plutonium for dose reconstruction (DR) purposes. Attachment A of the white paper develops the analyses of the plutonium bioassay data from NOCTS. Table A-1, page 18, summarizes the urinary excretion rates, in disintegrations per minute per day (dpm/d), obtained from the analyses of the bioassay data for the period 1967–1973.

- **Projection of potential plutonium intakes using urinalyses data** – Figures A-2 through A-16 in attachment A provide results obtained using the Integrated Modules for Bioassay Analysis (IMBA) program to project the potential intake values if using the bioassay results from table A-1. The resulting intake values are summarized in tables A-2 and A-3, page 19, and reproduced in tables 5 and 6, page 11, including a back extrapolation to 1965–1966.

2.3 Air measurement data 1976–1993

- **Source of air concentration measures** – There were gross alpha air concentration data taken in the plutonium areas at WRG and recorded in terms of percent of maximum permissible concentration (MPC) for the period 1976–1993.

- **Analyses of air measurement data** – Attachment C of the white paper presents an outline of the analyses of the MPC data. Table C-2, page 32, summarizes the annual air concentration data.

- **Intake modeling** – Attachment C briefly discusses the lognormal distribution fit of the air concentration data necessary to obtain the plutonium intake rates, which are summarized in table C-3, page 33, and reproduced in table 7, page 12, including a forward extrapolation to the period 1994–2011.

2.4 The 1974–1975 period without recorded data

There were not significant bioassay or air monitoring data during the period 1974–1975 to create a CW model for plutonium intakes at WRG. Therefore, NIOSH used an exponential decay curve fit between the intake rate for 1973 (from bioassay data) and the intake rate for 1976 (from measured air concentrations) to create intake rates for the years 1973 and 1974, according to methods recommended in ORAUT-OTIB-0070, *Dose Reconstruction During Residual Radioactivity Periods at Atomic Weapons Employer Facilities*, revision 01 (NIOSH, 2012). Table 8, page 13, in the white paper lists these intake rates for Type M plutonium and table 9, page 13, for Type S plutonium.

3 White Paper's Use of Coworker Guidelines

The *Draft Criteria for the Evaluation and Use of Coworker Datasets*, revision 4 (NIOSH, 2015) outlines NIOSH's CW data guidelines (hereafter referred to as the "Guide"). The four major criteria are (1) data adequacy, (2) data completeness, (3) review and analysis of monitoring program data, and (4) evaluation of stratification.

The white paper was evaluated for compliance with these general guidelines as outlined below.

1. **Section 2.1 of Guide: Data adequacy –** The bioassay data were specifically analyzed for plutonium. The air monitoring data gross alpha counting was assumed to be all plutonium. These data provided for adequate information to project potential plutonium intakes.

2. **Section 2.2 of Guide: Data completeness –** Most of the years of concern had some monitoring data. While the number of annual bioassays listed in table A-1, page 18, and the number of air samples listed in table C-2, page 32, are small compared to some U.S. Department of Energy (DOE) sites, they are useful for developing CW data for small AWE sites such as WRG, where a relatively small number of workers were potentially exposed to plutonium processed in limited and known areas (a minimum of 15 to 30 data points per time interval, or less for smaller operations, is recommended in NIOSH, 2015, page 7).

3. **Section 3.0 of Guide: Review and analysis of monitoring program data –** Attachment B of the white paper provides a record of instruction concerning the manipulation of the recorded data used to develop the CW data.

    - **Section 3.1 of Guide: Application of monitoring data to unmonitored workers –** Attachment D of the white paper discusses the plutonium bioassay program and its application to unmonitored workers for production and post-production periods and the decontamination and decommissioning (D&D) period.

    - **Section 3.2 of Guide: Analysis and application to the unmonitored population –** Attachment A of the white paper discusses the analyses of the recorded data and the derivation and application of the CW excretion and intake data. According to page 17 of the whitepaper "After extraction, these data were subjected to a 100% review for transcription errors and corrected as necessary."

    - **Section 3.3 of Guide: Time interval of the modeled data –** The gaps (1965–1966 and 1974–1975) in the available data are relatively small for plutonium compared to the years that data are available, as discussed in section 3.3.4 (pages 24–25) of ORAUT-OTIB-0060, revision 02, *Internal Dose Reconstruction* (NIOSH, 2018) and did not exceed 3 years as recommended in section 3.3 (page 10) of NIOSH (2015).

4. **Section 4.0 of Guide: Evaluation of stratification –** According to page 19 of the white paper, statistical analysis of the plutonium gross alpha bioassay data was performed in accordance with ORAUT-RPRT-0053, revision 02, *Analysis of Stratified Coworker Datasets* (NIOSH, 2014). However, considering the limited number of workers and work areas involved in the handling of plutonium at the WRG facility, the most likely exposed workers were monitored, and stratification is not indicated, or practical, as discussed in section 4.0, page 10, of NIOSH (2015).

4 SC&A's Evaluation of White Paper

The following summarizes SC&A's review of the white paper.

4.1 Bioassay data 1967–1973

SC&A reviewed the spreadsheets containing the plutonium bioassay data, which were derived from the NOCTS claim files that NIOSH used to perform excretion analysis for the period of plutonium production at WRG from 1967 to 1973. SC&A evaluated the methods, analyses, and IMBA runs used in attachment A of the white paper to derive the excretion rates (table A-1) and

the intake values (tables A-2 and A-3) and did not identify any errors or inappropriate assumptions. Tables 5 and 6, page 11, of the white paper summarize the derived intake rates. The intake values for 1967 were extended back to include the period of plutonium operations, January 1, 1965, through December 31, 1966, when no plutonium bioassay data were available. Therefore, SC&A had the following observation:

Observation 1: Extension of 1967 data to include 1965 and 1967
NIOSH stated on page 36 of the white paper, "The coworker intake rates for the 1967 through 1968 period should be used for 1965 and 1966 because no other data are available for that period." The absence of data does not provide very strong support for back-extending the 1967 data to cover the earlier period, especially since this was not a gap, but instead a beginning of operations with no intake data. A more detailed analysis addressing this issue and explaining why the earlier potential exposures were similar to, or no greater than, the 1967 exposures would have added support to this assumption. The importance of this issue is somewhat mitigated by the fact that an existing WRG Special Exposure Cohort (SEC) class for that period extends through 1970. That SEC class, however, was not based on the inability to recreate plutonium intake.

4.2 Air measurement data 1976–1993

SC&A evaluated the gross alpha air concentration data and the methods, analyses, and assumptions used by the white paper in attachment C to derive potential intakes. SC&A analyses did not identify any errors or inappropriate assumptions. Table C-2 (page 32) of the white paper summarizes the derived annual air concentration data, and table C-3 (page 33) lists the 50th and 95th percentile intake values. However, SC&A did have the following observation:

Observation 2: Use of 30 percent and 3.9 percent factor unclear
NIOSH states on page 37 of the white paper:

> The intakes from the 1976-1987 period were based on a concentration of 6.0×10^{-13} μCi/mL [microcurie per milliliter], or 30% of the MPC of plutonium, while the intakes for the 1988-1993 period were based on a concentration of 7.8×10^{-14} μCi/mL, or 3.9% of the MPC. The site was using an MPC of 2×10^{-12} μCi/mL.

It appears that the value of 30 percent was obtained from the 95th percentile value of 0.2994 MPC listed in figure C-1, page 34, and that the value of 3.9 percent was obtained from the 95th percentile value of 0.03877 MPC listed in figure C-2, page 35, of the white paper. However, the white paper does not explain why the 95th percentile inhalation intake value of 8.741 dpm/d (instead of 0.30×4.44 dpm/m^3 (cubic meter) $\times$ 1.2 m^3 per day $\times$ 8 hour per day = 12.79 dpm/d) is listed in table 7, page 12, and table C-3, page 33, for 1976–1987. Likewise, why is the 95th percentile inhalation intake value of 1.132 dpm/d (instead of 0.039×4.44 dpm/m^3 $\times$ 1.2 m^3 per day $\times$ 8 hours per day = 1.66 dpm/d) listed in table 7, page 12, and table C-3, page 33, for 1988–1993? One possible explanation is that NIOSH adjusted the intake values of 12.79 dpm/d from figure C-1 and 1.132 dpm/d from figure C-2 by an exposure factor of (250 day)/(365 day), which would have resulted in the values of 8.74 dpm/d and 1.13 dpm/d as listed in tables 7 and C-3. However, this is not stated in the white paper.

4.3 The 1974–1975 period without recorded data

SC&A evaluated the 1973 bioassay and 1976 gross alpha air concentration data and the methods, analyses, and assumptions used by the white paper on pages 13 and 14 to derive potential plutonium intake rates for the 1974–1975 data gap. SC&A analyses did not identify any errors or inappropriate assumptions. NIOSH analyses were performed correctly according to ORAUT-OTIB-0070 (NIOSH, 2012), using Equation 4-1, page 15, and recommendations in table 5-1, page 16. Table 8, page 13, of the white paper lists the derived 95th percentile intake values for Type M plutonium, and table 9, page 13, for Type S plutonium. SC&A did not identify any findings or observations in this section.

4.4 Decontamination and decommissioning period 1990–1993

The white paper does not address the D&D period in detail, except to mention on page 6 that individual bioassay data are presumed sufficient for all workers exposed to plutonium during the D&D period, and to provide a short discussion concerning radiological monitoring during the D&D period in attachment D, page 40. SC&A reviewed the bioassay data for the D&D period and found that approximately 16 workers submitted approximately 200 urine bioassay samples, which were analyzed for Pu-239 and total plutonium. A review of the urinalyses indicated that they were conducted on approximately quarterly bases. SC&A did not locate any in vivo lung count data in NIOSH's bioassay files for the D&D period. SC&A had the following observation:

Observation 3: Were in vivo bioassays required or performed for D&D workers?
SC&A reviewed the referenced Nuclear Fuel Services, *Plutonium Facilities, Decommissioning Project Plan, Condition Addendum* (NFS, 1989, PDF page 170), that states:

> Bioassay frequencies, at a minimum, will be quarterly for urine/fecal samples and annually for invivo lung counting.

It is not completely clear from this statement if the bioassay method could be urine/fecal sampling performed quarterly or in vivo lung counts performed annually, or if both were required.

5 Summary and Conclusions

SC&A's review of the white paper found that NIOSH used the recommended methods, per approved appropriate procedural documents, to derive reasonable CW data from the available recorded bioassay and air monitoring data. SC&A did not identify any findings, but did have three observations:

- **Observation 1: Extension of 1967 data to include 1965 and 1967** – NIOSH stated on page 36 of the white paper, "The coworker intake rates for the 1967 through 1968 period should be used for 1965 and 1966 because no other data are available for that period." The absence of data does not provide very strong support for back-extending the 1967 data to cover the earlier period, especially since this was not a gap, but instead a beginning of operations with no intake data. A more detailed analysis addressing this issue and explaining why the earlier potential exposures were similar to, or no greater than, the 1967 exposures would have added support to this assumption. The importance

of this issue is somewhat mitigated by the fact that an existing WRG SEC class for that period extends through 1970. That SEC class, however, was not based on the inability to recreate plutonium intake.

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> Bioassay frequencies, at a minimum, will be quarterly for urine/fecal samples and annually for invivo lung counting.

It is not completely clear from this statement if the bioassay method could be urine/fecal sampling performed quarterly or in vivo lung counts performed annually, or if both were required.

SC&A performed a focused review of the white paper to evaluate if the appropriate methods and procedures were used to analyze the available data and to derive internal CW intake values for WRG workers potentially exposed to plutonium during the period 1965–2011. This review did not include evaluating the numerous related NIOSH documents used in CW data development, as this would be beyond the tasking of this review.

6 References

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