Draft

ADVISORY BOARD ON
RADIATION AND WORKER HEALTH

National Institute for Occupational Safety and Health

A REVIEW OF NIOSH'S PROGRAM EVALUATION REPORT DCAS-PER-063, "ALUMINUM COMPANY OF AMERICA – PENNSYLVANIA (ALCOA-PN)"

Contract No. 211-2014-58081
SCA-TR-2017-PR008, Revision 0

Prepared by

Douglas Farver, CHP

SC&A, Inc.
2200 Wilson Boulevard, Suite 300
Arlington, Virginia, 22201

July 2017

SC&A, INC.: ***Technical Support for the Advisory Board on Radiation and Worker Health Review of NIOSH Dose Reconstruction Program***

DOCUMENT TITLE:	A Review of NIOSH's Program Evaluation Report DCAS-PER-063, "Aluminum Company of America – Pennsylvania (ALCOA-PN)"
DOCUMENT NUMBER/ DESCRIPTION:	SCA-TR-2017-PR008
REVISION NO.:	0 (Draft)
SUPERSEDES:	N/A
EFFECTIVE DATE:	July 17, 2017
TASK MANAGER:	Douglas Farver, CHP [signature on file]
PROJECT MANAGER:	John Stiver, MS, CHP [signature on file]
DOCUMENT REVIEWER(S):	John Stiver, MS, CHP [signature on file] Kathleen Behling [signature on file]

Record of Revisions

Revision Number	Effective Date	Description of Revision
0 (Draft)	7/17/2017	Initial issue

TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS

ABRWH or Board	Advisory Board on Radiation and Worker Health
ALCOA	Aluminum Company of America
ALCOA-PN	Aluminum Company of America – Pennsylvania
DCAS	Division of Compensation Analysis and Support
DF	depletion factor
dpm	disintegrations per minute
DR	dose reconstruction
FUSRAP	Formerly Utilized Sites Remedial Action Program
mR	milliroentgen
mrad	millirad
mrem	millirem
NIOSH	National Institute for Occupational Safety and Health
OCAS	Office of Compensation Analysis and Support
ORAUT	Oak Ridge Associated Universities Team
pCi	picocurie
PER	program evaluation report
POC	probability of causation
SRDB	Site Research Database
TBD	technical basis document

1.0 STATEMENT OF PURPOSE

To support dose reconstruction (DR), the National Institute for Occupational Safety and Health (NIOSH) and the Oak Ridge Associated Universities Team (ORAUT) have assembled a large body of guidance documents, workbooks, computer codes, and tools. In recognition of the fact that all of these supporting elements in DR may be subject to revisions, provisions exist for evaluating the effect of such programmatic revisions on the outcome of previously completed DRs. Such revisions may be prompted by document revisions due to new information, misinterpretation of guidance, changes in policy, and/or programmatic improvements.

The process for evaluating potential effects of programmatic changes on previously completed DRs has been proceduralized in OCAS-PR-008, *Preparation of Program Evaluation Reports and Program Evaluation Plans* (NIOSH 2006a), Revision 2, dated December 6, 2006. This procedure describes the format and methodology to be employed in preparing a program evaluation report (PER) and a program evaluation plan.

A PER provides a critical evaluation of the effects that a given issue/programmatic change may have on previously completed DRs. This includes qualitative and quantitative assessment of potential impacts. Most important in this assessment are the potential impacts on the probability of causation (POC) of previously completed DRs with POCs of <50%.

During a teleconference by the Advisory Board on Radiation and Worker Health's (Board's) Subcommittee for Procedure Reviews on January 10, 2017, SC&A was tasked by the Board to conduct reviews of four PERs. Included among the PERs is DCAS-PER-063, *Aluminum Company of America – Pennsylvania (ALCOA-PN)*, Revision 0 (NIOSH 2015; also referred to as "PER-063"). In conducting a PER review, SC&A is committed to perform the following five subtasks, each of which is discussed in this report:

Subtask 1: Assess NIOSH's evaluation/characterization of the "issue" and its potential impacts on DR. SC&A's assessment intends to ensure that the "issue" was fully understood and characterized in the PER.

Subtask 2: Assess NIOSH's specific methods for corrective action. In instances where the PER involves a technical issue that is supported by document(s) (e.g., white papers, technical information bulletins, procedures) that have not yet been subjected to a formal SC&A review, Subtask 2 will include a review of the scientific basis and/or sources of information to ensure the credibility of the corrective action and its consistency with current/consensus science. Conversely, if such technical documentation has been formalized and previously subjected to a review by SC&A, Subtask 2 will simply provide a brief summary/conclusion of this review process.

Subtask 3: Evaluate the PER's stated **approach** for identifying the universe of potentially affected DRs, and assess the **criteria** by which a subset of potentially affected DRs was selected for reevaluation. The second step may have important implications in instances where the universe of previously denied DRs is very large and, for reasons of practicality, NIOSH's reevaluation is confined to a subset of DRs that, based on their scientific

judgment, have the potential to be significantly affected by the PER. In behalf of Subtask 3, SC&A will also evaluate the timeliness of the completion of the PER.

Subtask 4: Conduct audits of DRs affected by the PER under review. The number of DRs selected for audit for a given PER will vary. (It is assumed that the selection of the DRs and the total number of DR audits per PER will be made by the Advisory Board.)

Subtask 5: Prepare a written report that contains the results of DR audits under Subtask 4, along with our review conclusions.

2.0 RELEVANT BACKGROUND INFORMATION

2.1 OVERVIEW OF FACILITY HISTORY

The Atomic Weapons Employer, Aluminum Company of America (ALCOA), had one site located in New Kensington, Pennsylvania. The facility, also known as Aluminum Research Laboratories; or the New Kensington Works (of ALCOA) on Pine and 9th Streets, conducted uranium slug canning operations as early as May 1943 and ending in 1945 (Foley and Brown 1992). The facility was listed as an Atomic Weapons Employer from 1943 through 1945. ALCOA was one of 14 facilities in the early 1940s that produced nuclear fuel for the X-10 pilot plant reactor in Oak Ridge, Tennessee and the production reactors at Hanford, Washington.

ALCOA used a unique welding process to “can” and seal uranium slugs produced by other facilities. Initiated in the spring of 1943, the work preceded under 15 purchase orders that resulted in the canning of approximately 100,000 slugs through 1945. Actual machining of uranium metal was apparently limited to experimental machine shop and laboratory situations (Young 1987).

3.0 SUBTASK 1: IDENTIFY THE CIRCUMSTANCES THAT NECESSITATED DCAS-PER-063

NIOSH performs DRs for the claims from the Aluminum Company of America – Pennsylvania (ALCOA-PN) using Appendix R to Battelle-TBD-6000, Revision 1, *Site Profiles for Atomic Weapons Employers that Worked Uranium Metals* (NIOSH 2011, also referred to as "TBD-6000, Revision 1"). Revision 1 to TBD-6000 was issued on June 17, 2011. Appendix R was originally issued (Revision 0) on April 30, 2007 (NIOSH 2007). Revision 1 to Appendix R was issued on March 5, 2014 (NIOSH 2014), to incorporate changes from the TBD-6000 revision and the use of methodology from ORAUT-OTIB-0070, Revision 01, *Dose Reconstruction During Residual Radioactivity Periods at Atomic Weapons Employer Facilities* (NIOSH 2012; also referred to as "OTIB-0070"), for the residual period. The revisions included changes to external dose values from contaminated surfaces, the conversion factor for photon and beta dose rates, and included addition of intakes from resuspension. Additionally, job classes used in Appendix R, Revision 0, were eliminated, and slug production doses were revised to match the values in Table 6.4 of TBD-6000, Revision 1. Also, the guidance from ORAUT-OTIB-0070 was added, regarding use of a depletion factor (DF) during this site's residual period.

4.0 SUBTASK 2: ASSESS NIOSH'S SPECIFIC METHODS FOR CORRECTIVE ACTION

4.1 JOB CATEGORIES

Revision 0 to Appendix R (NIOSH 2007) contained job classifications based on the employee's job function. Each claim was evaluated to determine the most appropriate job category corresponding to the job titles of Operator, General Laborer, Supervisor, and Clerk given in Tables 6.4 and 7.9 of TBD-6000, Revision 0 (NIOSH 2006c).

Revision 1 to Appendix R (NIOSH 2014) eliminates the job category determination and evaluates each case using the job title of the operator that has the highest internal and external dose parameters in Tables 6.4 and 7.8 of TBD-6000, Revision 1 (NIOSH 2011).

4.2 OPERATIONAL PHASE

4.2.1 Occupational Internal Dose

The ALCOA-PN facility conducted uranium slug canning operations from the spring of 1943 through 1945. Table 4-1 shows the inhalation and ingestion intake values for the operational phase given in both revisions to Appendix R (NIOSH 2007, 2014). The inhalation intakes are based on an air concentration of 264 disintegrations per minute per cubic meter (dpm/m^3), the mean air sampling value for the stamping slug category shown in Table 7.6 of TBD-6000, Revision 1. The operator is assumed to have a 75% exposure time, yielding an air concentration of 198 dpm/m^3.

Table 4-1. Operational Phase Intake Values

Years	Appendix R, Rev.1, Table R.1		Appendix R, Rev. 0, Tables R.1 and R.2 (max. values)	
	Inhalation Intake (pCi/day)	Ingestion Intake (pCi/day)	Inhalation Intake (pCi/day)	Ingestion Intake (pCi/day)
1943 to 1945	710	15	704	6.55

Assuming a working year of 2,400 hours and a breathing rate of 1.2 m^3/hour, the daily inhalation intake is calculated as follows:

$$\text{Inhalation (pCi/day)} = (198\ \text{dpm/m}^3) \times (1.2\ \text{m}^3\text{/hr}) \times (2{,}400\ \text{hr/yr}) \div (2.2\ \text{dpm/pCi} \times 365\ \text{day/yr})$$

$$= 710\ \text{pCi/day}$$

The ingestion intake rate is the sum of the food contamination and incidental hand-to-mouth ingestion rates, as shown in Section 7.1.6 of TBD-6000, Revision 1. The ingestion intake (I) in picocuries per day (pCi/day) is equal to the air concentration in dpm/m^3 multiplied by the work hours per year and a conversion factor of 3.062×10^{-5}.

$$I_{ing} = (3.062\times10^{-5}) \times (198\ dpm/m^3) \times (2{,}400\ hr/yr)$$

$$I_{ing} = 14.55\ pCi/day$$

The inhalation and ingestion intake values are given in Tables 7.8 and 7.9 of TBD-6000, Revision 1 (NIOSH 2011).

Although SC&A was able to confirm the inhalation and ingestion intake values cited in Appendix R, Revision 1, we were unable to determine how the Appendix R Revision 0 inhalation and ingestion intake values were determined, because Tables 7.8 and 7.9 did not change from Revision 0 to Revision 1. With the issuance of PER-063, this issue is no longer a concern.

4.2.2 Occupational External Dose

Table 4-2 shows estimated annual external doses for metalworking processes, as given in the Appendix R Revisions 0 and 1 (NIOSH 2007, 2014). With the exception of the whole-body photon dose in Appendix R, Revision 0, the values have remained the same, but the units have changed.

Table 4-2. Operational Phase External Doses

Years	Appendix R, Rev.1, Table R.2			Appendix R, Rev. 0, Tables R.3 and R.4 (max. values)		
	Whole Body Photon (mR/yr)	Skin (rad/yr)	Hand & Forearms (rad/yr)	Whole Body Photon (mR/day)	Skin (mrad/day)	Hand & Forearms (mrad/day)
1943 to 1945	2500	25	276	0.349	68.4	756

Skin Dose

Skin doses are estimated for (1) the hands and forearms of a worker who handles uranium metal (D_{hands}) and (2) other skin surfaces of a worker who handles the metal (D_{skin}). The assumptions used in the calculations are described in Section 6.3 of TBD-6000, Revision 1. The calculation for the hands and forearms assumes a contact dose rate of 230 millirem per hour (mrem/hr) for a 48-hour work week, 50 weeks per year, and hands in contact with the surface of the metal 50% of the workday.

$$D_{hands} = (230\ mrem/h \times mrad/mrem \times 48\ hours/week \times 50\ weeks/year)/2$$

$$D_{hands} = 276{,}000\ mrad/year = 276\ rad/year$$

Also, 276 rad/year divided by 365 days/year equals 0.756 rad/day or 756 millirad per day (mrad/day).

The dose to other skin on the worker's body that is not in direct contact with uranium metal is estimated to be 10 times the photon dose rate at 1 foot. Table 6.1 of TBD-6000, Revision 1

(NIOSH 2011), lists the dose rates from standard shapes of uranium metal. The maximum dose rate at 1 foot from a rectangular uranium ingot is 2.08 mrem/hour.

D_{skin} = (2.08 mrem/hour × 10 mrad/mrem × 48 hours/week × 50 weeks/year)/2

D_{skin} = 24,960 mrad/year = 25 rad/year

As with the previous, if 25 rad/year is divided by 365 days/year, it yields 68.4 mrad/day.

Whole-Body Dose

The whole-body photo dose (D_{wb}) is also derived using the photon dose rate at 1 foot from a rectangular uranium ingot. The same working-time assumptions apply.

D_{wb} = (2.08 mrem/hour × mR/mrem × 48 hours/week × 50 weeks/year)/2

D_{wb} = 2,496 mR/year

However, when 2,500 mR/year is divided by 365 days/year, it yields 6.84 mR/day, not 0.349 mR/day as shown in Table R3 of Appendix R, Revision 0. Table 6.4 of TBD-6000, Revision 0, shows the daily doses from penetrating photon radiation for a 48-hour work week as 6.84 mR/day. It is unclear how the whole-body photon dose of 0.349 mR/day given in Table R2 of Appendix R, Revision 0, was derived. With the issuance of PER-063, this issue is no longer a concern.

4.3 RESIDUAL PHASE

A Formerly Utilized Sites Remedial Action Program (FUSRAP) survey of ALCOA-PN was conducted on November 12, 1991. The results indicated no measured levels above U.S. Department of Energy-FUSRAP guidelines and no measured levels significantly different from typical background levels for the area. Therefore, no exposure to residual contamination is assumed after 1991. The facility's residual phase consists of the time period from 1946 through 1991.

The internal and external exposures at the beginning of the residual phase, 1946, are determined from air sampling data for facilities where uranium slugs were produced and canned. Table 7.6 of TBD-6000, Revision 1, shows air sample results for slug production. The air sampling data are used to calculate the surface contamination (Section 3.4.2 of TBD-6000, Revision 1) and guidance in Section 7.1.5 of TBD-6000, Revision 1, to derive the initial inhalation intake rate. The derived surface contamination and dose conversion factors in Section 3.4.2 are used to derive the external dose rates. The ingestion intake value is assumed to be the ingestion intake at the end of the operational phase (15 pCi/day). The external dose rate and internal intake rates are decreased throughout the residual period according to the guidance in OTIB-0070.

4.3.1 Internal

Table 7.6 of TBD-6000, Revision 1, shows the air sampling data for facilities where uranium slugs were produced and canned. The daily weighted average air concentration for an operator is

given as 198 dpm/m^3. Section 3.4 of TBD-6000, Revision 1, shows that the floor contamination level (C_{floor}) can then be estimated as:

C_{floor} (dpm/m^2) = Air Concentration (dpm/m^3) × 1,944 meters

C_{floor} (dpm/m^2) = 198 dpm/m^3 × 1,944 meters

C_{floor} (dpm/m^2) = 3.849 E+05 dpm/m^2

The inhalation intake rate (I_i) at the beginning of the residual time period is calculated by multiplying the floor contamination level by a 10^{-6} m^{-1} resuspension factor, breathing rate of 1.2 m^3/hr, and hours worked.

I_i (pCi/day) = (C_{floor} × 10^{-6} m^{-1} × 1.2 m^3/hr × 48 hr/wk × 50 wk/yr) ÷ (2.2 dpm/pCi × 365 days/yr)

I_i (pCi/day) = 1.38 pCi/day

Therefore, at the beginning of the residual period, the initial inhalation intake rate is 1.38 pCi/day and initial ingestion intake rate is 15 pCi/day, which represents the ingestion intake rate at the end of the operational period.

4.3.2 External

The floor contamination level and dose conversion factors from natural uranium surface contamination, as given in Table 3.10 of TBD-6000, were used to calculate the initial gamma and beta dose rates. Table 4-3 shows the surface contamination dose conversion factors.

Table 4-3. Surface Contamination Dose Conversion Factor (TBD-6000)

Time Since Separation	Photon Exposure Rate (mR/hr per dpm/m^2)	Beta Dose Rate (mrad/hr per dpm/m^2)
100 days	3.94E-10	3.82E-08

The photon, or whole body, exposure rate (D_γ) is calculated as follows:

D_γ (mR/yr) = C_{floor} × 3.94E-10 mR/hr per dpm/m^2 × 48 hr/wk × 50 wk/yr

D_γ (mR/yr) = 0.364 mR/yr

Similarly, the beta exposure rate (D_β) is used to calculate the dose rate to the skin, hands, and forearms:

D_β (mrad/yr) = C_{floor} × 3.82E-08 mrad/hr per dpm/m^2 × 48 hr/wk × 50 wk/yr

D_β (mrad/yr) = 35.3 mrad/yr

4.3.3 Source Depletion

The initial intake and dose rates were calculated for the first year of the residual time period. Because the facility is no longer operating, it is assumed the source on which the dose rates are based will decrease over time. Table 4.1 of OTIB-0070 lists source-term depletion rates during residual periods for various sites. The average depletion rate is 6.70E-04 d^{-1}. The DF decreases exponentially over time.

$$DF = e^{-\lambda t},$$

where λ equals 6.70E-04 d-1 and t is the time from the beginning of the residual time period in days. Table 4-4 shows the internal intake rates and external dose rates for the residual phase adjusted for source depletion.

Table 4-4. Exposure During the Residual Phase

Year	Depletion Factor	Internal Exposures – Inhalation (pCi/day)	Internal Exposures – Ingestion (pCi/day)	External Exposures – Photon (mR/yr)	External Exposures – Skin (mrad/yr)	External Exposures – Hand & Forearms (mrad/yr)
1946	1.00	1.38	15	0.364	35.3	35.3
1947	0.7831	1.08	11.75	0.285	27.6	27.6
1948	0.6132	0.85	9.20	0.223	21.6	21.6
1949	0.4802	0.66	7.20	0.175	16.9	16.9
1950	0.3760	0.52	5.64	0.137	13.3	13.3
1951	0.2944	0.41	4.42	0.107	10.4	10.4
1952	0.2305	0.32	3.46	0.084	8.1	8.1
1953	0.1805	0.25	2.71	0.066	6.4	6.4
1954	0.1414	0.20	2.12	0.051	5.0	5.0
1955	0.1107	0.15	1.66	0.040	3.9	3.9
1956	0.0867	0.12	1.30	0.032	3.1	3.1
1957	0.0679	0.09	1.02	0.025	2.4	2.4
1958	0.0532	0.07	0.80	0.019	1.9	1.9
1959	0.0416	0.06	0.62	0.015	1.5	1.5
1960-1969	0.0326	0.04	0.49	0.012	1.2	1.2
1970-1979	0.0028	0.0039	0.042	0.001	0.10	0.10
1980-1991	0.0002	0.00034	0.0037	0.0001	0.009	0.009

4.4 SC&A COMMENTS

SC&A was able verify the values in Tables R1 and R2 of Appendix R, Revision 1, using the guidance in the revised TBD-6000 (NIOSH 2011) and OTIB-0070. SC&A has no concerns with Subtask 2.

5.0 SUBTASK 3: EVALUATE THE APPROACH FOR IDENTIFYING POTENTIALLY AFFECTED DOSE RECONTRUCTIONS

NIOSH used the following set of criteria to determine the claims that potentially could have been affected by the revision to Appendix R:

1. A search for all previously completed claims from the ALCOA-PN facility
2. Claims that resulted in a POC of less than 50%

Using these criteria, NIOSH identified 44 claims that could potentially be affected by a revision to Appendix R. In DCAS-PER-063 (NIOSH 2015), NIOSH lists the following reasons for which cases were removed from further evaluation:

- [redacted] claims were completed using Revision 1 to Appendix R and were removed from further evaluation.
- [redacted] claims were completed using a complex-wide overestimating method (ORAUT-OTIB-0004), resulting in a higher dose estimate than Revision 1 to Appendix R. Those [redacted] claims were removed from further evaluation.
- [redacted] claims were returned to NIOSH and reworked using Revision 1 to Appendix R. Those claims also were removed from further evaluation.

NIOSH calculated new dose estimates for the remaining 35 claims using Appendix R, Revision 1, and current DR methods.

5.1 SC&A COMMENTS

SC&A believes that this basic strategy for identifying the potentially affected cases, and the screening criteria used to determine which cases need to be reevaluated, are appropriate.

6.0 SUBTASK 4: REVIEW OF CASES

NIOSH identified a total of 35 reevaluated claims. The POCs for those claims are as follows:

- Twenty-seven claims yielded POCs below 45%.
- [redacted] resulted in a POC between 45% and 50%.
- [redacted] claims exceeded a POC of 50%.

In order for SC&A to satisfy its commitment under Subtask 4, a single DR may be selected for review, provided the employment period at the site covers both the operational and residual periods. Alternatively, two DRs may be selected that represent the operational period and the residual period separately. SC&A would like to request the opportunity to review a sample set of the reevaluated cases to assess whether Revision 1 to Appendix R was implemented correctly.

7.0 REFERENCES

Foley and Brown 1992. R.D. Foley and K.S. Brown, *Results of the Radiological Survey at the Former ALCOA New Kensington Works, Pine and Ninth Streets, New Kensington, Pennsylvania (ANK002)*, ORNL/RASA-92/5, Oak Ridge National Laboratory, Oak Ridge, TN. October 1992. [SRDB Ref. ID 16445]

NIOSH 2006a. *Preparation of Program Evaluation Reports and Program Evaluation Plans*, OCAS-PR-008, Revision 2, Office of Compensation Analysis and Support, National Institute for Occupational Safety and Health, Cincinnati, OH. December 6, 2006.

NIOSH 2006b. *Estimating the Maximum Plausible Dose to Workers at Atomic Weapons Employer Facilities*, ORAUT-OTIB-0004, Revision 03 PC-2, National Institute for Occupational Safety and Health, Cincinnati, OH. December 6, 2006.

NIOSH 2006c. Site Profiles for Atomic Weapons Employers that Worked Uranium and Thorium Metals, Battelle-TBD-6000, Revision 0, National Institute for Occupational Safety and Health, Cincinnati, OH. December 13, 2006.

NIOSH 2007. *Site Profiles for Atomic Weapons Employers that Worked Uranium and Thorium Metals, Appendix R – Aluminum Company of America – Pennsylvania (Alcoa 1)*, Battelle-TBD-6000, Appendix R, Revision 0, National Institute for Occupational Safety and Health, Cincinnati, OH. April 30, 2007.

NIOSH 2011. *Site Profiles for Atomic Weapons Employers that Worked Uranium Metals*, Battelle-TBD-6000, Revision 1, National Institute for Occupational Safety and Health, Cincinnati, OH. June 17, 2011.

NIOSH 2012. *Dose Reconstruction During Residual Radioactivity Periods at Atomic Weapons Employer Facilities*, ORAUT-OTIB-0070, Revision 01, National Institute for Occupational Safety and Health, Cincinnati, OH. March 5, 2012.

NIOSH 2014. *Site Profiles for Atomic Weapons Employers that Worked Uranium Metals, Appendix R –Aluminum Company of America – Pennsylvania (ALCOA-PA)*, Battelle-TBD-6000, Appendix R, Revision 1, National Institute for Occupational Safety and Health, Cincinnati, OH. March 20, 2014.

NIOSH 2015. *Aluminum Company of America – Pennsylvania (ALCOA-PN)*, DCAS-PER-063, Revision 0, Division of Compensation Analysis and Support, National Institute for Occupational Safety and Health, Cincinnati, OH. June 15, 2015.

Young 1987. Letter from Charles D. Young, Project Engineer, The Aerospace Corporation, to Andrew Wallo, III, NE-23, Division of Facility & Site Decommissioning Projects, U.S. Department of Energy, *Recommendation for Site Visit Aluminum Company of America Site New Kensington, Pennsylvania*. November 18, 1987. [SRDB Ref. ID 9557, pp. 8–10]