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

A Review of NIOSH's Program Evaluation Report DCAS-PER-067, "Allegheny Ludlum Appendix Q Revision"

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Abbreviations and Acronyms

ABRWH, Board	Advisory Board on Radiation and Worker Health
AEC	Atomic Energy Commission
AL	Allegheny-Ludlum Steel Company
BL	Bliss and Laughlin Steel
BZ	breathing zone
DCAS	Division of Compensation Analysis and Support
dpm/m^3	disintegrations per minute per cubic meter
DR	dose reconstruction
GA	general area
GSD	geometric standard deviation
mrem/hr	millirem per hour
NIOSH	National Institute for Occupational Safety and Health
ORAUT	Oak Ridge Associated Universities Team
PER	program evaluation report
POC	probability of causation
SRDB	Site Research Database

1 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) 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.

A program evaluation report (PER) provides a critical evaluation of the effects that a given issue or programmatic change may have on previously completed DRs. This includes a qualitative and quantitative assessment of potential impacts. Most important in this assessment is the potential impact on the probability of causation (POC) of previously completed DRs with POCs less than 50 percent.

During a teleconference by the Advisory Board on Radiation and Worker Health (Board) Subcommittee for Procedure Reviews on February 16, 2023, the Board tasked SC&A to review DCAS-PER-067, revision 0 (NIOSH, 2016; "PER-067") which was issued to address the impacts of issuing revision 1 to Appendix Q of Battelle-TBD-6000 on previously completed claims (NIOSH, 2014). 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 and characterization of the issue addressed in the PER and its potential impacts on DR. Our 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. When the PER involves a technical issue that is supported by documents (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 and 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 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 Board will select the DRs and the total number of DR audits for each PER.)
- **Subtask 5:** Prepare a written report that contains the results of DR audits under subtask 4, along with our review conclusions.

2 Relevant Background Information

The Allegheny-Ludlum Steel Corporation (AL) plant in Watervliet, NY performed specialized metal rolling.

The AL plant rolled solid uranium rods from ingots in 1951 and 1952. Because additional rolling to produce the finished rods occurred elsewhere, the rods were referred to as "billets" at the AL plant. The uranium rolling operation started on a developmental scale and then transitioned into production-scale work. Other metalworking tasks, such as straightening, lathe work, and cutting with shears and stamping, also occurred at the site.

There were 16 rolling campaigns between January 20, 1951, and June 28, 1952. Starting on December 1, 1951, a salt bath furnace was introduced to the process, which reduced oxidation of the uranium metal and in turn reduced airborne contamination. At the end of operations in 1952, all uranium-bearing material was returned, and the site was cleaned.

The site has an Energy Employees Occupational Illness Compensation Program Act Atomic Weapons Employer covered operational period from 1951 through 1952. No exposure to residual contamination is assumed after 1952. It should be noted that there appears to be a typographical error in section Q.6 of Appendix Q, revision 1 (NIOSH, 2014; also called "the AL site profile"). The text states that "no residual contamination period was designated after 1951," but SC&A believes this should read "no residual period was designated after 1952," which is consistent with when uranium rolling operations ceased at AL.

Observation 1. Incorrect date for end of AWE operational period
When discussing the lack of a residual period, TBD-6000, Appendix Q, section Q.6, appears to incorrectly give the date of the end of operations as 1951 when it should be 1952.

3 Subtask 1: Identify the Circumstances that Necessitated DCAS-PER-067

3.1 Chronology of events

Dose reconstructions for claims from the AL plant are performed using Battelle-TBD-6000, "Site Profiles for Atomic Weapons Employers that Worked Uranium Metals" (NIOSH, 2011, "TBD-6000"), Appendix Q. Revision 0 of Appendix Q (NIOSH, 2007) was issued April 30, 2007. Revision 1 of Appendix Q was issued October 24, 2014, due to a revision of TBD-6000 in 2011. TBD-6000 was revised to include review comments and external beta dose from surface contamination.

Revision 1 of Appendix Q also included additional details about the uranium rolling campaigns and eliminated the various job categories, such that the same estimate is used for all employees. This change increased the inhalation dose estimates for many of the former job categories and increased the ingestion and external dose estimates for all former job categories.

PER-067 was issued in March 2016[1] to evaluate the effects on dose caused by Appendix Q, revision 1.

3.2 SC&A's comments

Programmatic revisions that may affect the outcome of previously completed DRs and mandate the need for a PER include any revisions to guidance documents that may result in the assignment of a higher dose. SC&A compared the assumptions in revision 1 to those in revision 0 and found that the ingestion and external dose estimates increase in all circumstances. It is more challenging to make a direct comparison to inhalation doses because of the many job categories in revision 0 that were removed in revision 1. Additionally, there is some ambiguity on how inhalation intakes in revision 0 should be assigned. Using what SC&A believes to be a reasonable interpretation of revision 0, SC&A found that most 1952 inhalation doses increase, while most 1951 inhalation doses decrease.

SC&A believes that the additional information regarding uranium rolling campaigns and the elimination of job categories for dose estimates is sufficient justification to reevaluate worker doses, as defined in PER-067 (NIOSH, 2016). SC&A concurs with NIOSH's decision to issue PER-067, and there are no findings.

It is important to note that SC&A has reviewed neither revision 0 nor revision 1 of Appendix Q. Therefore, SC&A's review of PER-067 includes an evaluation of Appendix Q for its guidance on dose reconstruction.

[1] PER-067 lists the authorization date of the document as March 16, 2011. Since the document addresses revision 1 of Appendix Q, issued in 2014, SC&A assumes the intended date of authorization is March 11, 2016.

4 Subtask 2: Assess NIOSH's Specific Methods for Corrective Action

The principal changes to the evaluation of doses in Appendix Q involve (1) the elimination of job categories for dose estimates and (2) the inclusion of additional rolling days, both of which resulted in higher inhalation, ingestion, and external dose estimates. SC&A's review of PER-067 focuses on these changes. Additionally, the review includes an evaluation of Appendix Q for its guidance on internal and external dose reconstruction because neither revision of appendix Q has been previously evaluated by SC&A.

4.1 Additional rolling campaign information

NIOSH located information about three additional rolling campaigns in 1951 and information about specific dates and totals for uranium rolling campaigns from January through June 1952. Each rolling campaign is summarized in table Q.1 of Appendix Q, revision 1, along with the supporting references.

4.1.1 SC&A comments

SC&A reviewed the Site Research Database (SRDB) documents cited by NIOSH for each of the rolling campaigns in table Q.1 of Appendix Q. Table Q.1 states that the first rolling campaign on January 20, 1951, rolled 25 ingots. SC&A reviewed SRDB document 10885 (AEC, 1951a) and found information to suggest the total number of ingots rolled may be 40. From the reference, it is unclear if the 15 ingots for DuPont were included in the 25 mentioned in the preceding line. SC&A could not find any other references that clarified this issue further. Additionally, revision 0 of Appendix Q included information on the 40 total ingots rolled during this campaign. Because the dose estimate calculations in Appendix Q are based on air concentration data and are not dependent upon the number of ingots rolled on a given workday, there is no impact to the dose estimates from this discrepancy. However, if these additional ingots required an additional day or two of rolling, then it would affect the dose estimates.

Observation 2: Discrepancy in the number of ingots rolled during January 20, 1951, campaign
There appears to be an unknown discrepancy in the number of ingots rolled during the first rolling campaign. However, it is SC&A's understanding that this does not affect the intake estimates.

SC&A determined that the remainder of the rolling campaign information in table Q.1 of Appendix Q, revision 1, was correctly summarized based on available information.

4.2 Inhalation dose estimate

As stated in PER-067, revision 1 of Appendix Q included additional rolling campaign details and eliminated dose estimates based on job categories, which resulted in increased doses for many of the former job categories.

Revision 1 of Appendix Q included estimates of the air concentration broken into two different time periods: before the implementation of a salt bath, and after implementation of a salt bath. AL began using a salt bath on December 1, 1951. The addition of the salt bath reduced the oxidation of the uranium, which reduced the amount of airborne uranium during operations. The

pre-salt bath uranium air concentration was estimated using air monitoring data from the first two rolling campaigns on January 21, 1951, and July 22, 1951.

The post-salt bath uranium air concentration was estimated using air monitoring data from one rolling campaign on February 9, 1952. NIOSH used the geometric mean of each period's data as the uranium air concentration for the inhalation intake calculations, which was 291 disintegrations per minute per cubic meter (dpm/m^3) for the pre-salt bath period, and 20.5 dpm/m^3 for the post-salt bath period. NIOSH assumed an 8.8-hour workday to calculate the uranium inhalation intakes and normalized the intakes per calendar day for the pre-salt bath and post-salt bath time periods.

To calculate the inhalation intakes on non-rolling days, NIOSH assumed the higher airborne activity concentration of 291 dpm/m^3 was allowed to deposit for 30 days at a rate of 0.00075 meters per second and used a resuspension factor of 1×10^{-5}.

4.2.1 SC&A comments

SC&A reviewed revision 1 of Appendix Q and confirmed that additional rolling campaign details were included, and that all workers would now receive the same dose estimate regardless of job title.

It is not clear to SC&A how the inhalation intakes would have been assigned using revision 0 of Appendix Q; therefore, it is difficult to determine if the inhalation intakes under revision 1 are in fact higher for most of the former job categories, as stated in PER-067.

SC&A was able to locate the air monitoring data NIOSH used to calculate the estimated uranium air concentrations. For the pre-salt bath period, there are 38 general area (GA) measurements and 5 breathing zone (BZ) measurements (AEC, 1951a). For the post-salt bath period, there are 48 GA measurements (AEC, 1952). Using these data, SC&A was able to match NIOSH's geometric mean calculations reported in section Q.4. SC&A also confirmed that NIOSH used the guidance in section 3.4.2 of TBD-6000 to calculate deposited surface contamination, which was then used to calculate the inhalation intakes from resuspended contamination.

SC&A used revision 1 of TBD-6000, Appendix D, for Bliss and Laughlin (BL) (NIOSH, 2017) to compare NIOSH's methodology for estimating inhalation intakes for uranium rolling operations. Bliss and Laughlin also performed uranium rod machining and straightening from 1951 to 1952. According to revision 01 of Appendix D (NIOSH, 2017, pp. 2–3):

> An analysis of 20 total samples (13 BZs and 7 GAs) was conducted. The analysis showed that the measured air concentrations could be represented by a lognormal distribution with a geometric mean of 2,602 dpm/m^3 with a geometric standard deviation (GSD) of 2.04. This was compared to the default air concentration value of 5,480 dpm/m^3 contained in Table 7.5 of Battelle-TBD-6000 for an operator machining uranium. Because of the limited number of air samples, the air concentration value from Battelle-TBD-6000 was determined to be more claimant-favorable and was utilized to determine inhalation and ingestion quantities during years of AEC operations at Bliss and Laughlin.

SC&A notes that the number of air samples provided for both sites (AL and BL) are not drastically different but also notes that, in the BL case, a greater proportion of the available samples were BZ. In evaluation of BL data, NIOSH determined the data were insufficient to use and elected to assign the TBD-6000 standard values in table 7.5. There are limited air sample results available for AL. Only five of the 1951 air sample measurements were BZ, and none of the 1952 air samples were BZ. It is unclear if the available samples represent the full range of values that may have been encountered by workers at AL. The estimated uranium air concentrations for AL of 291 dpm/m^3 and 20.5 dpm/m^3 are significantly lower than the values from TBD-6000 and BL. This may reflect the fact that a greater proportion of BL air samples were BZ rather than GA, or it may reflect different operational processes between the two locations despite both involving uranium rolling operations. SC&A requests clarification on why the two different approaches were adopted for AL (i.e., use of the air sampling data) versus BL (i.e., use of standard TBD-6000 values).

Observation 3. Inconsistency with NIOSH's approach to calculating uranium intakes from air sampling data

SC&A notes that the methods to utilize air sampling data for the purpose of reconstructing uranium intakes are different between two uranium rolling sites (Allegheny Ludlum and Bliss and Laughlin) and requests clarification on the different approaches.

4.3 Ingestion dose estimate

PER-067 states that the calculated ingestion intakes increased for all former job categories in revision 1 of Appendix Q. NIOSH used OCAS-TIB-009, revision 0 (NIOSH, 2004; "TIB-009"), and stated that it likely resulted in an overestimate of the actual ingestion intake, as TIB-009 assumes operations occurred often enough for airborne contamination levels to reach a maximum. Uranium ingestion was estimated for all workdays, and the resulting intakes were normalized over a calendar year.

4.3.1 SC&A comments

SC&A reviewed the ingestion intakes from revision 1 of Appendix Q and confirmed that the intakes are higher than those previously calculated for the various job categories in revision 0. SC&A found that NIOSH selected the highest calculated geometric mean air concentration, 291 dpm/m^3, and multiplied it by 0.2 to calculate the ingestion rate of 58.2 dpm/workday or 39.9 dpm/calendar day in table Q.4. The multiplier of 0.2 comes from section 5.0 of TIB-009. The 0.2 value is derived from the sum of modes 2 and 3 ingestion types.

The default assumptions in TIB-009 for mode 2 ingestion (material in the air settles out onto food or drink, which is later ingested) assume an 8-hour workday. NIOSH used the default assumptions to calculate ingestion intakes of 58.2 dpm/workday (39.9 dpm/calendar day) in Appendix Q, table Q.4. However, inhalation assumptions at AL assume an 8.8-hour workday. To be consistent with the calculations, SC&A believes it is more appropriate to assume an 8.8-hour workday for ingestion also. This would result in a 1.7 dpm/calendar day increase in the ingestion rate. However, SC&A further notes that assumptions such as using the higher airborne contamination rate would far outweigh any such effects from recalculating the TIB-009 ingestion factor.

Observation 4: Assumed work day length for ingestion calculations inconsistent with assumed work day length for inhalation calculations
SC&A notes that the TIB-009 factor is based on an 8-hour day and that it would be appropriate for consistency to modify the TIB-009 factor to 8.8 hours per day assumed for Allegheny-Ludlum. However, this is offset by other conservative assumptions in the ingestion model.

4.4 External dose estimate

No external dosimetry records have been located from AL. Revision 1 of Appendix Q uses the dose rates given in TBD-6000 to estimate occupational external dose from uranium work at AL. NIOSH assumed that operators are assumed to be exposed to the 1-foot dose rates in TBD-6000 50 percent of the time, and that hands and forearms are assumed to be exposed to the contact dose rate 50 percent of the time.

4.4.1 SC&A comments

SC&A reviewed the external dose calculations and confirmed that the dose estimates increased from revision 0 of Appendix Q. SC&A found that NIOSH used the 1-foot photon dose rate for a rectangular ingot from TBD-6000, table 6.1, of 2.08 millirem per hour (mrem/hr) and assumed that the 1-foot beta dose rate is 10 times this value, consistent with the guidance from section 6.3 of TBD-6000 (NIOSH, 2011). SC&A also found that NIOSH used the contact beta dose rate of 230 mrem/hr from section 6.3 of TBD-6000 to calculate the dose to the hands and forearms. Additionally, SC&A agrees that NIOSH's assumptions for the fraction of time operators are exposed to the 1-foot and contact dose rates are consistent with sections 6.2 and 6.3 of TBD-6000 (NIOSH, 2011). NIOSH also calculated external dose from deposited contamination using the surface contamination estimate calculated for ingestion intakes, along with the conversion factors from table 3.10 of TBD-6000, and assumed workers were exposed to this contamination for 8.8 hours a day, 250 days a year.

4.5 Occupational medical dose

No information regarding occupational medical dose specific to AL was found in either revision 0 or revision 1 of Appendix Q. Therefore, Appendix Q remained unchanged in its guidance of referring to ORAUT-OTIB-0006, revision 04, for assigning occupational medical dose in DRs. It should be noted that in revision 1 of Appendix Q, NIOSH references revision 03 PC-1 of ORAUT-OTIB-0006 but includes the date for revision 04. SC&A believes NIOSH intended to reference revision 04 of ORAUT-OTIB-0006 (ORAUT, 2011), as this was the current revision at the time revision 1 of Appendix Q was written.

4.5.1 SC&A comments

SC&A reviewed Appendix Q and agrees with the guidance of using ORAUT-OTIB-0006, as no AL-specific information exists for occupational medical dose.

5 Subtask 3: Evaluate the PER's Stated Approach for Identifying the Number of DRs Requiring Reevaluation of Dose

5.1 NIOSH's selection criteria

Section 3.0 of PER-067 described the following criteria NIOSH used to identify previously completed claims requiring reevaluation using guidance in revision 1 of Appendix Q (NIOSH, 2014). First, NIOSH identified all previously completed claims with verified employment at AL that had a POC of less than 50 percent. This identified 26 claims. One of these claims had been completed using revision 1 of Appendix Q and was removed from further evaluation. The remaining 25 claims were reevaluated by NIOSH using revision 1 of Appendix Q, as well as other applicable approved DR methods. After reevaluating the claims, NIOSH found that for 23 claims, the POC was below 45 percent. The remaining two claims were found to have a POC greater than 52 percent. In response to this evaluation, NIOSH stated the following:

> NIOSH will provide the Department of Labor with the list of all claims evaluated under this PER. Further, NIOSH will request the return of the 2 claims that would now result in a probability of causation greater than 50%. [NIOSH, 2016, p. 2]

5.2 SC&A's comments

Since NIOSH's selection criteria included all AL claims not previously compensated, SC&A believes NIOSH's selection criteria are sufficiently broad to capture all cases impacted by the issuance of revision 1 of Appendix Q. SC&A believes it is appropriate that NIOSH further limited the selection criteria to cases not already completed using revision 1 of Appendix Q. Additionally, SC&A believes the PER was conducted in a timely manner, as revision 1 of Appendix Q was issued in October 2014, and PER-067 was issued in March 2016. There are no findings associated with subtask 3.

6 Subtask 4: Conduct Audits of a Sample Set of Reevaluated DRs Mandated by DCAS-PER-067

Previous sections of this report described changes introduced in revision 1 of the AL site profile (NIOSH, 2014) that increased the assigned dose. SC&A recommends that the Board select two cases of the 25 evaluated by NIOSH for additional evaluation:

1. SC&A recommends reviewing one case involving a worker whose employment includes rolling campaigns with and without a salt bath.

2. Additionally, SC&A recommends reviewing another case involving a worker whose previous job category (such as administrative) in the old DR led to a lower intake rate.

7 References

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