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NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

ADVISORY BOARD ON RADIATION AND WORKER HEALTH

REVIEW OF NIOSH/ORAUT PROCEDURES AND METHODS USED FOR DOSE RECONSTRUCTION

A REVIEW OF NIOSH'S PROGRAM EVALUATION REPORT DCAS-PER-038, "HOOKER ELECTROCHEMICAL TBD REVISION"

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ABBREVIATIONS AND ACRONYMS

ABRWH	Advisory Board on Radiation and Worker Health
DCAS	Division of Compensation Analysis and Support
dpm	disintegrations per minute
IREP	Interactive RadioEpidemiological Program
MCNPX	Monte Carlo N-Particle eXtended
mr	milliroentgen
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
PEP	Program Evaluation Plan
PER	Program Evaluation Report
POC	probability of causation
SC&A	S. Cohen and Associates (SC&A, Inc.)
TBD	Technical Basis Document

EXECUTIVE SUMMARY

SC&A has been requested by the Advisory Board on Radiation and Worker Health (ABRWH) to conduct an audit of the Program Evaluation Report (PER) OCAS-PER-0038, *Hooker Electrochemical TBD Revisions*, which was prompted by revisions to *Appendix AA – Hooker Electrochemical Company* of TBD-6001. These revisions were incorporated into a stand-alone technical basis document (TBD), *Technical Basis Document for the Hooker Electrochemical Company*, DCAS-TKBS-0009 (DCAS 2011a).

In OCAS-PER-038, NIOSH developed criteria to screen claims that had been reviewed prior to the publication of DCAS-TKBS-0009 for the impact of any changes to dose reconstructions that would result from use of the Hooker TBD. NIOSH found that 53 claims met the screening criteria for re-examination. Of these, 33 claims were eliminated for various reasons, such as the worker had already been classified in a job that maximized doses. Probabilities of causation (POCs) were calculated for the remaining 20 claims and for every claim, the POC was less than 50%. SC&A believes that the claim selection criteria in the PER properly identified the population of claims requiring re-examination and that the PER was being correctly implemented given the changes to the TBD. However, there may be a need for additional changes to the TBD based on SC&A's recent review of that document. The findings from that review have not yet been considered by NIOSH and the appropriate ABRWH Work Group.

1.0 STATEMENT OF PURPOSE

To support dose reconstruction, 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 dose reconstruction may be subject to revisions, provisions exist for evaluating the effect of such programmatic changes on the outcome of previously completed dose reconstructions. 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 impacts of programmatic changes on previously completed dose reconstructions has been documented in OCAS-PR-008, *Preparation of Program Evaluation Reports and Program Evaluation Plans*, Revision 2 (OCAS 2006). That document describes the format and methodology to be employed in preparing a Program Evaluation Report (PER) and a Program Evaluation Plan (PEP).

A PER provides a critical evaluation of the effect(s) that a given issue/programmatic change may have on previously completed dose reconstructions. A PER includes a qualitative and, in some cases, quantitative assessment of potential impacts. Most important in this assessment is the potential impacts on the probability of causation (POC) of previously completed dose reconstructions with POCs of <50%.

As needed, a PEP may be issued that serves as a formal notification of an impending PER. The PEP provides a preliminary description of the issue(s) that will be addressed in the PER, and summarizes the likely scope of the effort required to complete the PER.

SC&A has been tasked by the Advisory Board to conduct an audit of DCAS-PER-038, *Hooker Electrochemical TBD Revision* (DCAS 2012). In conducting the PER review, SC&A is committed to perform five subtasks, each of which is discussed in this report.

2.0 SUBTASK 1: IDENTIFY THE CIRCUMSTANCES THAT NECESSITATED THE NEED FOR DCAS-PER-038

On June 15, 2006, NIOSH issued *Appendix AA – Hooker Electrochemical Company* (Battelle 2007) to Battelle-TBD-6001(Battelle 2006). The purpose of Appendix AA was to describe the use of TBD-6001 for performing dose reconstructions for Hooker employees.

Based on initial reviews, NIOSH determined that TBD-6001 should be cancelled and that the various site-specific appendices to that report would be re-issued as stand-alone TBDs. On April 4, 2011, NIOSH issued DCAS-TKBS-0009, *Technical Basis Document for Hooker Electrochemical Company* (DCAS 2011a), replacing Appendix AA. Changes noted by NIOSH included:

> *Changes Battelle-TBD-6001 Appendix to a standalone document. Revises dose models to eliminate dependence on Battelle-TBD-6001. Provides more detailed description of dose models. Incorporate review comments.*

Subsequently, on June 17, 2011, NIOSH issued Revision 1 to DCAS-TKBS-0009 with the following changes (DCAS 2011b):

> *Revision initiated to correct errors in Tables 2, 3, and 6. Renumber tables after Table 4. Added language on page 10 to indicate the 95th percentile of the airborne values was used. Corrected typographical errors on page*[s] *7 and 14.*

On July 24, 2012, NIOSH issued DCAS-PER-038 to address the impacts that use of DCAS-TKBS-0009 Revision 0 and Revision 1 would have on previously completed dose reconstructions.

It is important to note that, after the PER was issued, SC&A was requested by the ABRWH to review DCAS-TKBS-0009. SC&A's review published in March 2013 identified several findings that have not been yet been discussed and resolved (SC&A 2013). Based on the review presented here, SC&A concludes that the criteria developed in the PER to select claims for review and the methods used to review these selected claims against TKBS-0009 are appropriate. However, until SC&A's findings regarding TKBS-0009 are resolved, an open issue remains as to whether the claims were reviewed against a technically correct baseline. For completeness, SC&A's findings based on its review of DCAS-TKBS-0009 are listed below.

> *Finding 1. NIOSH should review the assumptions regarding the composition of the incoming slag and the outgoing concentrate in light of the new material provided in Thomas 1944.*

> *Finding 2: NIOSH should re-examine its position that external exposures were based on slag input to the leaching process of 10 tons per month. It is possible that external exposures are understated by a factor of about 5.*

Finding 3. The basis for assuming that internal exposure from slag dust occurred 5% of the time needs to re-examined as does the assumption that the concentrate contained 2% U. It appears that the exposure time is understated by about a factor of five and the amount of uranium in the concentrate is understated by at least a factor of 2.5.

Finding 4: NIOSH should review the ingestion intake to ensure that it is calculated in a manner consistent with calculation of the inhalation intake.

Finding 5: NIOSH should confirm that the correct units of measure are cited in Tables 2 and 3.

Finding 6: NIOSH should review the units of measure for the photon DCF in Table 4 and determine if they are correct. If the units are correct, the text needs to be revised to discuss exposure rates rather than dose rates.

It is apparent that some of these findings have implications regarding the doses received by Hooker employees.

3.0 SUBTASK 2: ASSESS NIOSH'S EVALUATION/CHARACTERIZATION OF THE ISSUES AND THEIR POTENTIAL IMPACTS ON DOSE RECONSTRUCTION

Under Subtask 2, SC&A is to ensure that PER issue(s) is/are fully addressed and characterized in the PER.

Section 2.0 of PER-038 notes that no doses or intakes were higher in Revision 1 than in Revision 0 of TKBS-0009. (See Attachment A from TKBS-0009 included here also as Attachment A). Consequently, comparisons were made between Revision 1 and Appendix AA.

Inhalation intakes were marginally higher for "operators" in Appendix AA, but were lower for all other job categories compared to Revision 1. Inhalation intakes for the residual period were unchanged. Consequently, the internal dose during the residual period did not need to be reconsidered.

The external gamma dose was lower in Revision 1 for both the operational and residual periods. External doses to the hands and forearms and to the skin other than the hands and forearms were lower in Revision 1 for the operational period but higher for the residual period.

Based on this assessment, doses that increased in Revision 1 compared to Appendix AA included:

- Inhalation intakes during the operational period for all job categories except "operators"
- Skin doses during the residual period for all job categories

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4.0 SUBTASK 3: ASSESS NIOSH'S SPECIFIC METHODS FOR CORRECTIVE ACTION

In this section, we assess the methods proposed by NIOSH to address the impacts of the increased doses summarized in Section 3 on completed dose reconstructions. We note that SC&A recently completed a review of Revision 1 of TKBS-0009 (SC&A 2013). During this review, SC&A uncovered new material suggesting that some of the assumptions in Revision 1 of TKBS-0009 may require further revision.

SC&A examined all relevant changes introduced in DCAS-TKBS-0009, Revision 1 (and Revision 0) that gave rise to DCAS-PER-038 and observes the following:

(1) Changes introduced in DCAS-TKBS-0009 added radiation exposure for external skin dose during the residual period which was not considered in Appendix AA.

(2) Changes in DCAS-TKBS-0009 reduced external radiation exposure from both photons and electrons during the operating period because of improved modeling using MCNPX to calculate doses. Originally, Appendix AA had relied on empirical data from TBD-6001, which was cancelled. These revisions were based on credible science or employed reasonable, plausible assumptions that were claimant favorable.

(3) Changes in DCAS-TKBS-0009 increased internal exposures to non-operators because differentiation by job category was eliminated—a simplifying, claimant-favorable assumption. Operator exposure was used for all job categories in the TBD.

The corrective action implemented by NIOSH was to develop criteria based on these changes to Appendix AA to select claims requiring review, and then to recalculate the POCs to determine if these changes altered the prior conclusions regarding the selected claims. SC&A agrees with the NIOSH corrective action approach.

5.0 SUBTASK 4: EVALUATE THE PER'S STATED APPROACH FOR IDENTIFYING THE UNIVERSE OF POTENTIALLY AFFECTED DOSE RECONSTRUCTIONS; AND ASSESS THE CRITERIA BY WHICH A SUBSET OF POTENTIALLY AFFECTED DOSE RECONSTRUCTIONS WAS SELECTED FOR RE-EVALUATION

In Section 3.0 of DCAS-PER-038 titled, "Plan for Resolution or Corrective Action," NIOSH notes that two populations were considered. Criteria for the first population are:

1. *Probability of Causation (PC) less than 50%*
2. *Most recent version of the dose reconstruction approved by DCAS on or prior to April 4, 2011 (issue date of revision 0 of the TBD. Revision 1 decreased doses from there).*
3. *Employed at the Hooker Electrochemical between 1946 and 1976 (residual period).*
4. *Diagnosed with a skin cancer (only the shallow dose was increased).*

NIOSH identified 14 claims that met the criteria for the first population.

Criteria for the second population are:

1. *Probability of Causation (PC) less than 50%*
2. *Most recent version of the dose reconstruction approved by DCAS on or prior to April 4, 2011 (issue date of revision 0 of the TBD. Revision 1 decreased doses from there).*
3. *Employed at the Hooker Electrochemical between 7/11/1944 and 1/15/1946 (operational period).*

NIOSH identified 39 claims that met the criteria of the second population. Of these, 33 claims were based on the "plant-floor high" or operator job category. Since the inhalation intakes for this category were slightly higher in Appendix AA than in Revision 1 to TKBS-0009, these claims required no further review.

For the remaining 20 claims, NIOSH recalculated the dose using the information in Revision 1 of TKBS-0009, and then calculated the POC for each claim using the Interactive RadioEpidemiological Program (IREP). For 19 claims, the POC was less than 45%, indicating that no further action was required. The remaining claim had a POC between 45% and 50%. NIOSH procedures require that if the initial POC estimate is within that range, 30 additional runs of 10,000 iterations each must be made and averaged (http://www.cdc.gov/niosh/ocas/ocasirep.html). NIOSH determined that even with the augmented number of IREP runs, the POC remained below 50%.

To summarize: Of the claims reviewed prior to the publication of DCAS-TKBS-0009 and for which the calculated POC was less than 50%, NIOSH identified a total of 20 claims for which

dose reconstructions needed to be redone. POCs for these claims were recalculated and, in every case, based on Revision 1 to DCAS-TKBS-0009, the POC remained below 50%. SC&A concurs that the selection criteria used by NIOSH do, in fact, encompass the universe of potentially affected dose reconstructions and that none of these dose reconstructions exceed a 50% POC using Revision 1 of DCAS-TKBS-0009 as the basis of comparison. However, as discussed in Section 2, SC&A has recently reviewed TKBS-0009 and made several findings which have not yet been resolved.

6.0 SUBTASK 5: CONDUCT AUDITS OF DOSE RECONSTRUCTIONS AFFECTED BY OCAS-PER-038

The selection and number of dose reconstructions to be audited by SC&A will be made by the Advisory Board. SC&A recommends that such audits be deferred until the resolution of findings on Revision 1 of DCAS-TKBS-0009.

7.0 REFERENCES

Battelle 2006. *Site Profiles for Atomic Weapons Employers that Refine Uranium and Thorium*. Battelle-TBD-6001. Revision F0. December 13, 2006.

Battelle 2007. *Site Profiles for Atomic Weapons Employers that Refine Uranium and Thorium – Appendix AA Hooker Electrochemical Company*. Battelle-TBD-6001, Appendix AA. June 15, 2007.

DCAS (Division of Compensation Analysis and Support) 2011a. *Technical Basis Document for the Hooker Electrochemical Company*, Rev. 0. DCAS-TKBS-0009. Division of Compensation Analysis and Support, National Institute for Occupational Safety and Health, Cincinnati, Ohio. April 4, 2011.

DCAS 2011b. *Technical Basis Document for Hooker Electrochemical Company*, Rev. 1. DCAS-TKBS-0009. Division of Compensation Analysis and Support, National Institute for Occupational Safety and Health, Cincinnati, Ohio. June 17, 2011.

DCAS 2012. *Hooker Electrochemical TBD Revisions*. Program Evaluation Report. DCAS-PER-038. Division of Compensation Analysis and Support, National Institute for Occupational Safety and Health, Cincinnati, Ohio. July 24, 2012.

OCAS 2006. *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, Ohio. December 6, 2006.

SC&A 2013. *Review of the NIOSH Technical Basis Document for the Hooker Electrochemical Company, DCAS-TKBS-0009*. SCA-TR-SP2013-0034, Rev. 0. SC&A, Inc., Vienna, Virginia. March 2013.

Thomas, W.G., 1944. *Technical Report – Concentration of C-2 Slag*. M-4562. OSTI Identifier 4337668. http://www.osti.gov/energycitations/servlets/purl/4337668.

ATTACHMENT A: COMPARISON OF ASSIGNED DOSES AND INTAKE RATES (SOURCE – DCAS 2012)

The "Plant Floor High" job category in Appendix AA is equivalent to the "Operator" job category in the TBD. The "Plant Floor Low" job category in Appendix AA is equivalent to the "Laborer" job category in the TBD.

Inhalation Intakes

	App. AA	Rev. 0	Rev. 1
Operational – Operator	343 dpm/day	340 dpm/day	340 dpm/day
Operational – Laborer	172 dpm/day	340 dpm/day	340 dpm/day
Operational – Supervisor	85.8 dpm/day	340 dpm/day	340 dpm/day
Operational – Clerical	8.58 dpm/day	340 dpm/day	340 dpm/day
Residual – All	2.2 dpm/day	2.2 dpm/day	2.2 dpm/day

Ingestion intakes are proportional to the inhalation intakes in each revision
Appendix AA inhalation rates converted from pCi/day to dpm/day

External Gamma

	App. AA (mr/year)	Rev. 0 (mr/year)	Rev. 1 (mr/year)
Operational – Operator	147	14.755	1.885
Operational – Laborer	73.4	0.455	0.455
Operational – Supervisor	36.9	0.228	0.228
Operational – Clerical	3.69	0.0228	0.0228
Residual – Operator	137	0.455	0.455
Residual – Laborer	68.6	0.455	0.455
Residual – Supervisor	34.3	0.228	0.228
Residual – Clerical	3.43	0.0228	0.0228

Appendix AA values converted from mr/day to mr/year

External skin (other than hands and forearms)

	App. AA (mrem/year)	Rev. 0 (mrem/year)	Rev. 1 (mrem/year)
Operational – Operator	358	334.5	69.9
Operational – Laborer	179	40.5	40.5
Operational – Supervisor	87.6	20.3	20.3
Operational – Clerical	7.3	2.03	2.03
Residual – Operator	0	40.5	40.5
Residual – Laborer	0	40.5	40.5
Residual – Supervisor	0	20.3	20.3
Residual – Clerical	0	2.03	2.03

Appendix AA values converted from mrem/day to mrem/year

External skin (hands and forearms)

	App. AA (mrem/year)	Rev. 0 (mrem/year)	Rev. 1 (mrem/year)
Operational – Operator	4,015	1,310.5	167.5
Operational – Laborer	2,007	40.5	40.5
Operational – Supervisor	986	20.3	20.3
Operational – Clerical	110	2.03	2.03
Residual – Operator	0	40.5	40.5
Residual – Laborer	0	40.5	40.5
Residual – Supervisor	0	20.3	20.3
Residual – Clerical	0	2.03	2.03

Appendix AA values converted from mrem/day to mrem/year