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**ADVISORY BOARD ON
RADIATION AND WORKER HEALTH**

National Institute for Occupational Safety and Health

**SC&A REVIEW OF DCAS-TKBS-0009, REVISION 02 FOR
HOOKER ELECTROCHEMICAL COMPANY**

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ABBREVIATIONS AND ACRONYMS

ABRWH	Advisory Board on Radiation and Worker Health
DCAS	Division of Compensation Analysis and Support
ER	evaluation report
dpm	disintegrations per minute
dpm/hr	disintegrations per minute per hour
dpm/m ²	disintegrations per minute per square meter
dpm/m ³	disintegrations per minute per cubic meter
Electromet	Electro Metallurgical Company
HCl	hydrochloric acid
Hooker	Hooker Electrochemical Company
MCNP	Monte Carlo N-Particle
MED	Manhattan Engineer District
MgF ₂	magnesium fluoride
mr/hr	milliroentgen per hour
mrad/hr	millirad per hour
mrem/hr	millirem per hour
NIOSH	National Institute for Occupational Safety and Health
SEC	Special Exposure Cohort
SRDB	Site Research Database
TBD	technical basis document
U	uranium
UF ₄	uranium tetrafluoride
URAWE	Uranium Refining Atomic Weapons Employers

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1.0 INTRODUCTION

In April 2016, SC&A was tasked (Katz 2016) to review the revised *Technical Basis Document for the Hooker Electrochemical Company*, DCAS-TKBS-0009, Revision 02 (NIOSH 2015b; “TKBS-0009”) and determine whether it addressed SC&A’s 2013 findings about Revision 01 of this technical basis document (TBD) (SC&A 2013). This report presents SC&A’s review of TKBS-0009, Revision 02. SC&A 2013 had identified six findings based on its review. As discussed here, SC&A recommends that four of the findings be closed, but that additional information is required on two of the findings.

2.0 BACKGROUND

The Hooker Electrochemical Company (Hooker) in Niagara Falls, New York, processed so-called “C-2 slag” from July 11, 1944, through January 15, 1946 (NIOSH 2011b). The operations at Hooker involved the treatment of C-2 slag from the nearby Electro Metallurgical Company (Electromet) with hydrochloric acid (HCl) to increase the slag’s uranium content. The C-2 slag from Electromet was a byproduct of the bomb reduction process in which uranium tetrafluoride (UF₄) was exothermically reacted with magnesium metal to produce uranium metal. Dolomite was used as the refractory liner in the steel bomb at that point in time (NIOSH 2011b). After 1948, recycled magnesium fluoride (MgF₂) was used as the liner. The dolomite was high-fired or fused, resulting in a product with the approximate formula CaO·MgO. The HCl was excess acid produced at Hooker under an Atomic Energy Commission contract as a byproduct from the non-radioactive P-45 process.

In 2007, the National Institute for Occupational Safety and Health (NIOSH) issued the original site profile for Hooker (NIOSH 2007) as Appendix AA to Battelle-TBD-6001, *Site Profiles for Atomic Weapons Employers that Refine Uranium and Thorium* (NIOSH 2006; “TBD-6001”). As an appendix to TBD-6001, the Hooker site profile relied heavily on the parent document for dose reconstruction guidance. Based on a May 2010 request by the Advisory Board on Radiation and Worker Health (ABRWH), SC&A performed a review of Appendix AA and reported 10 findings (SC&A 2010). Several of the findings related to TBD-6001, upon which much of Appendix AA was based. TBD-6001 was subsequently cancelled by NIOSH, and alternate modeling approaches were used in revising the Hooker site profile.

Subsequently, at the TBD-6001 Work Group Meeting held in Cincinnati, Ohio, on November 4, 2010, the Work Group requested SC&A to prepare a focused review of the Hooker petition evaluation report (ER) on Petition SEC-00141, prepared by NIOSH (NIOSH 2010). Since the ER contained new information developed since Appendix AA was issued in 2007 (Battelle 2007), the Work Group felt that a focused review of the new information was needed. In response to this tasking, SC&A provided a focused review of the ER in January 2011 (SC&A 2011) in which SC&A made nine findings.

After the 2010 SC&A review of Appendix AA, NIOSH converted it to a stand-alone site profile or TBD published on April 4, 2011 (NIOSH 2011a) and issued a revision to that document on June 17, 2011 (NIOSH 2011b).

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According to NIOSH, the following changes were made in NIOSH 2011a:

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

In Revision 01 of the Hooker TBD, NIOSH described the changes as follows (NIOSH 2011b):

Revision initiated to correct errors in Tables 2, 3, and 6 [of NIOSH 2011a]. Renumber Tables after Table 4. Added language on page 10 to indicate 95th percentile of the airborne values was used. Corrected typographical error on pages 7 and 14.

At the January 2013 meeting of the Procedures Work Group, SC&A was authorized to conduct a critical review of NIOSH 2011b. During that review, SC&A uncovered some information that had not been utilized in prior reviews of Hooker. This new information dealt with quantities and uranium content of the C-2 slag. The critical review resulted in six findings, which are documented in SC&A 2013 (SCA-TR-SP2013-0034).

NIOSH issued Revision 02 to the Hooker site profile in December 2015 (NIOSH 2015b) with the stated purpose:

Revision initiated to include information about a Special Exposure Cohort designation for Hooker. Revision also incorporates changes due to new information describing the operations at Hooker.

As noted above, this report reviews DCAS-TKBS-0009, Revision 02 and makes a determination as to whether SC&A's 2013 findings were satisfactorily addressed.

3.0 REVIEW OF SC&A FINDINGS

3.1 FINDING 1

Finding 1. NIOSH should review the assumptions regarding the composition slag and the outgoing concentrate.

SC&A 2013 states (page 10):

There is some uncertainty as to the uranium content and composition of the slag. ...the uranium content is stated on page 29 of MED 1944 as 1%. However, on page 30 of MED 1944, it is stated that, "slag is concentrated from about 1 lb to 5 or 10 lb by weight." If the barrel [of incoming slag] contained 1 lb of uranium in 500 lb of slag, then the initial composition would be 0.2% (as assumed in NIOSH 2010, NIOSH 2011 a and b, and SC&A 2010) not 1% as stated in MED 1944 (p. 29);

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Therefore, SC&A 2013 concludes the following (page 12):

Based on the information presented here [SC&A 2013], it is plausible to assume that the concentration of uranium in the incoming slag and in the resultant concentrate is at least five times higher than assumed in the TBD.

Another factor to consider is estimating the external dose from slag handling. The +20 mesh fraction, which was not subject to acid digestion but did require handling, amounts to about 20% of the slag mass and contains 9% U (Thomas 1944). The contribution from this higher uranium content material needs to be included in the external exposure estimate.

In response to the new information provided in SC&A 2013, NIOSH revised the suppositions about slag composition to assume that the fines in the slag (80% of the total) contained 0.84% uranium (U), while the lumps (20% of the total) contained 9.87% U, resulting in an average concentration in the slag of 2.65% U.

SC&A is satisfied, that, with the revised slag and concentrate concentrations, the concerns regarding Finding 1 have been adequately addressed and proposes that the finding be closed.

3.2 FINDING 2

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.

As described on page 13 of SC&A 2013:

Information in Thomas 1944 supports the idea that the input to the Hooker process was more than 10 tons per month. Thomas notes that the availability of HCl at Hooker was sufficient to concentrate 65 to 80 tons per month. In addition, equipment was sized for an 80-ton per month acid leaching plant at Hooker.

In Revision 02 to DCAS-TKBS-0009 (NIOSH 2015b), NIOSH examined three production scenarios based on differing interpretations of the available information. NIOSH concluded that Scenario 3, involving processing 89 tons of slag monthly to produce 10.4 tons of wet concentrates, was most consistent with the available information. We concur with NIOSH that Scenario 3 is the best fit for the somewhat ambiguous information. The revised analysis satisfies SC&A's concerns about external exposure from slag handling and we propose that this finding be closed.

3.3 FINDING 3

Finding 3: The basis for assuming that internal exposure from slag dust occurred 5% of the time needs to be 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.

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As shown in Table 1 of TKBS-0009, Revision 02, NIOSH has now assumed that the concentrate contained 9.87% U wet basis or 5.87% U dry basis. Use of these revised assumptions satisfies SC&A's concerns regarding uranium concentration in the concentrates. Additionally, NIOSH assumed in Revision 02 of TKBS-0009 that slag handling would occur 2 hours per work day or 25% of the time, rather than 5% of the time previously assumed. Based on these revisions, we propose that Finding 3 be closed.

3.4 FINDING 4

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

SC&A recognizes that workers at Hooker have been added to the Special Exposure Cohort (SEC) for the operational period (November 1, 1945, through October 11, 1976) based on lack of air concentration data at the site for all of the operational period. However, inhalation and ingestion intakes are needed to assess operational exposures resulting in cancers not specified under the Energy Employees Occupational Illness Compensation Program Act of 2000 regulations and to calculate inhalation and ingestion exposures during the residual period. NIOSH states that inhalation intakes during the residual period are 3.2 disintegrations per minute (dpm) per calendar-day, presumably based on resuspended surface contamination of 0.404 dpm/m³, a breathing rate of 1.2 m³/hr, an 8-hour work day, and 300 work days per 365 calendar days (NIOSH 2015b, Table 7). However, NIOSH does not address ingestion exposures during the residual period.¹ Ingestion during the residual period has been the subject of recent deliberations by the Uranium Refining Atomic Weapons Employers (URAWE) Work Group (NIOSH 2015c), and it was determined that the procedures for the operational period as described in OCAS-TIB-009, *Estimation of Ingestion Intakes* (OCAS 2004), were not appropriate for the residual period. Ingestion exposures are apparently higher than inhalation exposures during the residual period because of an increase of hand-to-mouth transfer relative to inhalation in low-dust environments. For example, NIOSH showed, for the DuPont Deepwater site, that ingestion during the residual period was 100 times the inhalation intake (NIOSH 2015a, Section 6.0).

NIOSH states in Section 4.1 of TKBS-0009, Revision 02 that the airborne concentration is used in the residual contamination section to calculate the surface contamination and the resulting internal and external doses. Based on this statement, the surface concentration based on 30 days of continuous deposition is:

$$208 \text{ dpm/m}^3 \text{ (avg. air conc.)} \times 0.00075 \text{ m/s} \times 3,600 \text{ sec/hr} \times 24 \text{ hr/day} \times 30 \text{ days} = 404,352 \text{ dpm/m}^2$$

This is a very conservative approach, since it assumes 24-hour-per-day deposition and no degradation of surface contamination over time. As noted above, using this limiting surface concentration, the inhalation intake is 3.2 dpm per calendar day. Using the approach from

¹ While ingestion is not mentioned in the text of TKBS-0009, Revision 02, OCAS-TIB-009 (OCAS 2004) is cited in the list of references but not linked to the text.

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DCAS-TKBS-0006 (NIOSH 2015a) and the hand-to-mouth transfer factor from NUREG/CR-5512 (NRC 1992) to calculate the ingestion intake results in the following:

$$1.1\text{E-}04 \text{ m}^2/\text{hr} \times 404,352 \text{ dpm}/\text{m}^2 = 44.5 \text{ dpm}/\text{hr}$$

While SC&A expects that ingestion exposures will be small, they should be addressed for completeness in TKBS-0009.

3.5 FINDING 5

Finding 5: NIOSH should confirm that the correct units of measure are cited in Tables 2 and 3. [Tables 3 and 4 in NIOSH 2015b]

In its prior review, SC&A noted that the photon exposure was expressed differently in Tables 2 and 3 (SC&A 2013). Both tables include the phrase “External Dose Rate” in the titles, but the units of measure in Table 2 (now Table 3) are mr/hr while the units in Table 3 (now Table 4) are mrem/hr. Based on the information provided in the text of Revisions 1 (NIOSH 2011b) and 2 (NIOSH 2015b) of TKBS-0009, SC&A concluded that the units of measure in Table 2 should be mrem/hr and noted that the distinction was important because it can have a significant impact when selecting organ dose conversion factors from OCAS-IG-001, Revision 03, *External Dose Reconstruction Implementation Guidelines* (OCAS 2007).

We also note that, in Table 2, the beta dose is expressed in units of mrad/hr, while in Table 3 the units are in mrem/hr. SC&A recognizes that, for beta dose, the units are equivalent but, in the interests of clarity, consistent units should be used.

Since the cited tables were not revised between Revision 01 (NIOSH 2011b) and Revision 02 (NIOSH 2015b), SC&A believes that Finding 5 has not been resolved.

During the current review, SC&A uncovered some concerns regarding Table 5 in Revision 02 (NIOSH 2015b). The dose rates in the third column of that table are not correct. The correct value of the exposure (not dose) rate should be $2.74\text{E-}04 \text{ mr}/\text{hr}$ ($6.79\text{E-}10 \text{ mr}/\text{hr}$ per $\text{dpm}/\text{m}^2 \times 404,314 \text{ dpm}/\text{m}^2$). Based on a 6-day work week, 50 weeks per year, the photon exposure rate would be $0.659 \text{ mr}/\text{yr}$, which agrees with the value in Table 6. So, the error in Table 5 was not propagated. Similarly, the beta dose rate in Table 5 should be $2.44\text{E-}02 \text{ mrem}/\text{hr}$ ($58.6 \text{ mrem}/\text{yr}$), not $1.669 \text{ E-}02 \text{ mrem}/\text{yr}$. Again, the error in the Table 5 beta dose rate was not propagated into Table 6.

We note that the Monte Carlo N-Particle (MCNP) surface contamination conversion factors in Table 5 (NIOSH 2015b) were based on the dose rate (or exposure rate) at 1 foot from the contaminated surface. This is in contrast to the methodology in Revision 01 of Batelle-TBD-6000, *Site Profiles for Atomic Weapons Employers that Worked Uranium Metal* (NIOSH 2011c; “TBD-6000”), where the dose rate was determined at 1 meter from the contaminated surface. While the calculational approach for Hooker is more claimant favorable, it is not apparent why the already vetted values from TBD-6000 were not used.

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We also note an apparent error in Table 7 of TKBS-0009, Revision 02. It appears that the photon doses for the residual period are incorrect. The stated photon doses are actually beta doses to the skin.

3.6 FINDING 6

Finding 6: NIOSH should review the units of measure for the photon dose conversion factors in Table 4 [now Table 5] and determine if they are correct. If they are correct, the companion text needs to be revised to discuss exposure rates rather than dose rates.

Table 4 (NIOSH 2015b) listed the photon conversion factor as 6.79E-10 mr/hr per dpm alpha/m² and the dose rate as 1.90E-04 mr/hr. If the units are correctly stated, then the table and the text need to refer to the photon parameters as exposure rates. This remains to be clarified.

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