Resolution of Site Profile Issues for the Carborundum Company Niagara Falls, New York

White Paper

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INTRODUCTION

The S. Cohen & Associates (SC&A) review of SEC Petition 225 of January 27, 2016, identified seven Issues (Anigstein, 2016). All the Issues were either closed or considered site profile issues. In addition, SC&A also identified several other Issues/Findings during the review of NIOSH's use of surrogate data and review of NIOSH responses and updated methods (NIOSH, 2017) and draft example dose reconstructions provided to the Carborundum Work Group (Work Group) on March 2, 2017. The additional issues were identified in memoranda to the Carborundum Work Group on November 16, 2016, March 12, 2017, and June 30, 2017 (Anigstein and Mauro, 2016; 2017a; 2017b).

Some of the site profile issues were discussed and closed by the Work Group during meetings held on August 18, 2016, November 17, 2016, and March 13, 2017 (Work Group 2016a, 2016b, 2017). The resolution of some site profile issues remain unresolved by NIOSH and the Work Group. Table A-1 in Attachment A lists the various issues and findings and the status of each, including those already closed (or with agreed resolutions). Table 1 below lists nine Issues/Findings/Observations whose resolution has not previously been agreed to by NIOSH and the Work Group. Note that final resolution on a number of the issues will be implemented by NIOSH in an updated site profile document once agreement is reached on resolution of the remaining open issues. The issues that NIOSH intends to resolve by changes to doses or intakes specified in the site profile are identified with the "Update site profile" phrase in the third column of the tables.

Table 1: Open Site Profile Issues

Open site profile Issues	Reference	Resolution/Status
Dose from X ray Diffraction	SC&A January 27, 2016 March 12, 2017 June 30, 2017	**See NIOSH response below in text.**
Use of surrogate external dose data in 2nd Operational Period	SC&A November 10, 2016 NIOSH October 27, 2016 Work Group March 13, 2017 transcripts	**See NIOSH response below in text.** Update site profile.
Finding 4.1.1 Inconsistent work-hours used in residual dose calculations	SC&A June 30, 2017	NIOSH has updated all the site profile calculations to agree with work-hours in Battelle-TBD-6000. The following number of work-hours per year are used in updated calculations: 2,400 for 1943-1950, 2,200 for 1951-1955, and 2,000 for 1956 to end. Update site profile.
Finding 4.1.2 Incorrect distribution type used for external doses in example DR for 1959 and 1960.	SC&A June 30, 2017	NIOSH corrected an error in a table in the draft site profile spreadsheet. Update site profile.
Finding 4.1.3 Incorrect source term and glovebox model used to model dose from plutonium	SC&A June 30, 2017 January 27, 2016	**A white paper with revised dose estimates was provided to Work Group in August 2018 (NIOSH, 2018).** Update site profile.
Finding 4.1.5 Workers exposed to glovebox operations should be assigned intakes of both uranium and plutonium	SC&A June 30, 2017	**See NIOSH response in text of this memo.**

Open site profile Issues	Reference	Resolution/Status
Finding 4.1.6 Incorrect worker intake category used in one of the Example DRs.	SC&A June 30, 2017	NIOSH agrees with the SC&A comment. There was an error in the intake value used in the draft Example DR. No action needed by NIOSH.
Observation 4.2.1 SC&A commented that the methods to assign residual external dose using only the 30-250 keV energy band in the Example DRs resulted in a small overestimate of dose	SC&A June 30, 2017	NIOSH used the method to simplify dose calculations. As indicated in the SC&A memo the dose difference is favorable to the claimant, but not significant. In the example mentioned by SC&A, the simplified calculation resulted in about a 0.1% overestimate of total dose. No action needed by NIOSH.
Observation 4.2.2 SC&A commented that the method NIOSH used to calculate ingestion intakes in the 2nd Operational Period resulted in a slightly lower dose as opposed to the methods described in OCAS-TIB-009.	SC&A June 30, 2017	The total dose difference is insignificant; however, NIOSH updated the spreadsheet used for the site profile to agree with the SC&A comment. Update site profile.

Three of the issues in Table 1 referred to the text for response. Those three issues are discussed below.

ISSUE: DOSE FROM X-RAY DIFFRACTION

SC&A commented on the need for NIOSH to make adjustments in the calculations of external dose from X-Ray Diffraction (XRD). Comments included the recommendation to increase work-hour estimates of exposure in proximity to the XRD unit, application of a 2.48 factor to the dose rates proposed by NIOSH to adjust dose rates for instrument efficiency for the 8.0 keV and 8.9 keV characteristic photons from the copper target used by the Carborundum XRD unit. SC&A also commented that organ doses should be calculated using more appropriate dose conversion factors (DCFs) than the 30-250 keV DCFs NIOSH used in the draft Example DRs.

NIOSH Resolution: NIOSH agrees to adopt the more favorable assumptions recommended by SC&A for exposure time and to apply the 2.48 factor to adjust the dose rate for instrument response to the low energy photons. These adjustments result in an annual exposure of 1.033 R to the XRD operator, as recommended by SC&A in their March 12, 2017, memorandum to the Work Group.

NIOSH also agrees that more appropriate organ DCFs should be applied. SC&A suggested NIOSH use the mode value of the <30 keV DCF category. However, NIOSH performed organ dose calculations using more precise organ dose conversions for the characteristic photons (8.0 keV and 8.9 keV). Factors for <0.010 MeV photons from ICRP Publication 74 (ICRP, 1996) were used to estimate organ doses. The 1.003 R/yr exposure was converted to air kerma (0.00877 Gy/R), resulting in an annual dose of 0.008796 Gy/yr. Organ doses, in Gy, were then calculated using the ICRP 74 factors for 10 keV photons (organ dose per unit kerma free-in-air) found in Tables A.2 through A.20. The organ doses were then converted to units of rem. The various organ doses ranged from zero rem to a maximum of 0.267 rem. NIOSH then compared the organ doses from an XRD Operator to doses from a Laborer (support worker) in the uranium fabrication area. The uranium area work assumption provides the larger dose and will be used for dose reconstructions because NIOSH cannot determine precise work locations for all workers at all times.

ISSUE: USE OF SURROGATE EXTERNAL DOSE DATA IN 2ND OPERATIONAL PERIOD

The Work Group discussed NIOSH's use of surrogate data during the November 17, 2016, meeting (Work Group, 2016b); it was agreed that NIOSH needed to revise the external dose rate values. In the February 22, 2017, response paper to the Work Group, NIOSH presented updated dose estimates from exposure to uranium using surrogate data, and the updated doses were discussed during the Work Group meeting on March 13, 2017. At that time concurrence was reached on the updated photon dose rates; however, SC&A commented that the beta dose rates provided by NIOSH may underestimate actual dose rates at one foot from the source and overestimate the contact dose rate. The beta dose rate issue was determined to be a site profile issue and referred back to NIOSH for further evaluation. Subsequently, SC&A provided copies of their MCNP files and calculations of beta dose rates.

NIOSH Resolution:

NISOH reviewed the calculations provided by SC&A and agrees that the beta dose rates modeled by SC&A are appropriate. Those calculations indicate a contact beta dose rate of 77.6 mrem/hour and a one foot dose rate of 4.05 mrem/hour. NIOSH plans to use those dose rates in an updated site profile. For an Operator, those dose rates result in an annual whole body beta dose of 4.05 rem per year and a beta dose of 77.6 rem per year to the hands and forearms. Doses to other workers will be adjusted accordingly.

ISSUE: FINDING 4.1.5, WORKERS EXPOSED TO GLOVEBOX OPERATIONS SHOULD BE ASSIGNED INTAKES OF BOTH URANIUM AND PLUTONIUM

SC&A commented that plutonium workers should be assigned intakes of both uranium and plutonium during the 2nd Operational Period in 1961 through 1967, a period during which both uranium and plutonium were used to fabricate mixed carbide fuel pellets. SC&A concluded it is "illogical to assume that a worker who was externally exposed to the fabrication of uranium-plutonium pellets would be assigned intakes that consisted only of uranium aerosols." SC&A further noted that "plutonium can make significant contributions to internal doses."

NIOSH Response:

The intake methods described by NIOSH in the response paper of February 22, 2017, that were the subject of SC&A Finding 4.1.5, are favorable, and NIOSH proposes no changes to the intake methods presented in that paper. The rationale is provided below.

Uranium work in the 2nd Operational Period started in 1959. The plutonium work started in 1961 and involved both uranium and plutonium in the fabrication of mixed carbide fuel pellets. There was a separate uranium laboratory used for experiments and fabrication of uranium (only) experimental pieces and fuel pellets. NIOSH estimated intake rates in the uranium laboratory based on measured alpha air concentrations in the uranium laboratory. The plutonium laboratory was an isolated cell in the same building; operations with plutonium started in 1961. NIOSH estimated intake rates from the plutonium cell based on measured alpha air concentrations in the plutonium laboratory. In the absence of definitive work locations for all workers, NIOSH intends to assign intakes from whichever work area provides the higher dose. The choice of using one or the other areas of exposure, but not both, is based on the assumption that a worker is not simultaneously exposed in two different areas of the Carborundum facility. The alpha intake rates in the uranium laboratory are higher than the alpha intake rates in the plutonium area.

The uranium laboratory air concentrations are interpreted as 100% uranium alphas because no other alpha emitting radionuclides have been identified in those areas, although intakes of other radionuclides that may have been present in recycled uranium are applied as a function of the uranium intakes.

The plutonium laboratory used both uranium and plutonium in the fabrication of fuel pellets. The intakes are based on alpha air concentration estimates. Since workers could have been exposed to either uranium or plutonium, or a mixture, NIOSH intends to assign intakes from whichever element provides the higher internal dose for the claimant.

For the situation of alpha intakes in the plutonium laboratory, NIOSH performed scoping calculations for dose to the various organs per unit intake of Pu-239 and U-234; those scoping calculations indicated plutonium usually, but not always, provided the higher organ dose per unit intake. Since the alpha air concentrations in the plutonium cell could have been uranium, plutonium, or a mixture, dose reconstructions should interpret alpha intakes for exposure in the

plutonium cell as either plutonium or uranium, whichever results in the higher dose. However, if an assumption of uranium is made, the uranium laboratory always provides the highest dose because the intakes are higher. Thus, the highest internal dose can be determined by a choice between 100% plutonium alphas for the plutonium laboratory or 100% uranium alphas in the uranium laboratory.

SC&A also mentioned that it was not logical to assume external exposure to plutonium fuel pellets in the plutonium laboratory while assuming internal exposure to uranium in the uranium laboratory. NIOSH agrees in principle; however, NIOSH assumes that a worker could have been exposed in both laboratories for portions of their work. NIOSH intends to apply the more favorable internal and external doses separately to ensure total doses are not underestimated.

REFERENCES

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Work Group (Advisory Board on Radiation and Worker Health, Carborundum Work Group), 2016a, transcripts of the Carborundum Work Group, August 18, 2016. [SRDB Ref ID: 172565].

Work Group, 2016b, transcripts of the Carborundum Work Group, November 17, 2016. [SRDB Ref ID: 172566].

Work Group, 2017, transcripts of the Carborundum Work Group, March 13, 2017. [SRDB Ref ID: 172564].

ATTACHMENT A

Table A-1: List of Issues Identified by SC&A Review

Issue	Reference	Status
Dose from X ray Diffraction (SEC Issue 1)	SC&A January 27, 2016 March 12, 2017 June 30, 2017	Closed as SEC Issue by Work Group on 8/18/2016 and 3/13/2017. **Open site profile Issue-see Table 1.**
Possible exposure from thorium contamination (SEC Issue 2)	SC&A January 27, 2016	Closed as SEC Issue by Work Group on 8/18/2016. Closed as site profile Issue by Work Group on 3/13/2017.
Possible exposure from Sr-90 source (SEC Issue 3)	SC&A January 27, 2016	Closed by Work Group on 8/18/2016.
Medical x-ray dose during 1st Operational Period (SEC Issue 4)	SC&A January 27, 2016	Closed by Work Group on 8/18/2016. Update site profile.
Medical x-ray dose during 2nd Operational Period (SEC Issue 5)	SC&A January 27, 2016	Closed by Work Group on 8/18/2016.
Use of Federal Guidance Report 12 factors (SEC Issue 6)	SC&A January 27, 2016	Closed by Work Group on 8/18/2016. Update site profile.
Doses in Example DR not reproducible (SEC Issue 7)	SC&A January 27, 2016	Closed by Work Group on 3/13/2017.
Use of surrogate external dose data in 1st Operation Period	SC&A November 10, 2016 March 12, 2017 NIOSH October 27, 2016	Closed by Work Group on 3/13/2017. Update site profile.
Use of surrogate external dose data in 2nd Operation Period	SC&A November 10, 2016 March 12, 2017 NIOSH October 27, 2016	Closed as SEC Issue by Work Group on 3/13/2017. **Open site profile Issue-see Table 1.**
Finding 4.1.1 Inconsistent work-hours used in residual dose calculations	SC&A June 30, 2017	**Open site profile Issue-see Table 1.**

Issue	Reference	Status
Finding 4.1.2 Incorrect distribution type used for external doses in example DR for 1959 and 1960.	SC&A June 30, 2017	**Open site profile Issue-see Table 1.**
Finding 4.1.3 Incorrect source term and glovebox model used to model dose from plutonium	SC&A June 30, 2017 January 27, 2016	**Open site profile Issue-see Table 1.**
Finding 4.1.4 Incorrect surrogate organ used for medical x-ray dose to kidney in Example DR; incorrect standard deviation used for medical x-ray to lung in Example DR	SC&A March 13, 2017 June 30, 2017	That was an error in draft example DR, as discussed in Work Group meeting on 3/13/2017. No action needed by NIOSH.
Finding 4.1.5 Workers exposed to glovebox operations should be assigned intakes of both uranium and plutonium	SC&A June 30, 2017	**Open site profile Issue-see Table 1.**
Finding 4.1.6 Incorrect intake category used in one of the Example DRs.	SC&A June 30, 2017	**Open site profile Issue-see Table 1.**
Observation 4.2.1 SC&A commented that the methods to assign residual external dose using only the 30-250 keV energy band in the Example DR resulted in a small overestimate of dose	SC&A June 30, 2017	**Open site profile Observation-see Table 1.**
Observation 4.2.2 SC&A commented that the method NIOSH used to calculate ingestion intakes in the 2nd Operational Period resulted in a slightly lower dose as opposed to the methods described in OCAS-TIB-009	SC&A June 30, 2017	**Open site profile Observation-see Table 1.**