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National Institute for Occupational Safety and Health

Review of ORAUT-OTIB-0084, Revision 00

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Abbreviations and Acronyms

ABRWH	Advisory Board on Radiation and Worker Health
IMBA	Integrated Modules for Bioassay Analysis
µg/L	micrograms per liter
mL/d	milliliters per day
NIOSH	National Institute for Occupational Safety and Health
NMI	Nuclear Metals, Inc.
ORAUT	Oak Ridge Associated Universities Team
pCi/d	picocuries per day
pCi/µg	picocuries per microgram
SRDB	Site Research Database
TBD	technical basis document

1 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. One of those documents is ORAUT-OTIB-0084, revision 00, "Internal Coworker Dosimetry Data for Nuclear Metals, Inc." (ORAUT, 2013; "OTIB-0084"). OTIB-0084 provides monitored co-exposure information for calculating and assigning occupational internal doses to employees at Nuclear Metals, Inc. (NMI) for whom no or insufficient monitoring records exist.

In November 2024, SC&A was tasked by the Advisory Board on Radiation and Worker Health's Subcommittee for Procedure Reviews to review OTIB-0084 (ORAUT, 2013).

2 Background

On October 29, 1958, NMI moved to West Concord, Massachusetts.[1] NMI operated as an Atomic Weapons Employer facility from 1958 through 1990, with a residual period from 1991 through 2011. NMI produced depleted uranium products for armor-piercing ammunition; supplied copper-plated uranium billets for Savannah River's production reactors; and manufactured metal powders for medical applications, photocopiers, and other applications. NMI also handled thorium and thorium oxides, though to a lesser extent than the uranium source terms.

3 Bioassay Data Selection

NIOSH obtained NMI urinalysis bioassay data from historical site documents. It was found that in many instances a given bioassay result was reported more than once. NIOSH evaluated the data and removed results that were deemed to be duplicates. This was done by first using computerized matching criteria of potential duplicates, which were then manually evaluated for the potential to represent a duplicate sample.

NIOSH collected and analyzed bioassay data from 1978 through 2000. Prior to 1978, little bioassay data exists, and NIOSH stated that 2000 was the last year with a complete data set. NIOSH considered only uranium fluorometric bioassay data and excluded records for other radionuclides. NIOSH did not exclude data from any radiological incidents that may have occurred, which is generally not appropriate for co-exposure modeling but is a claimant-favorable approach. The bioassay data were converted from mass units to activity units assuming a uranium specific activity of 0.36 picocuries per microgram (pCi/µg), which was noted in some NMI bioassay results. To then convert the data into units of pCi per day (pCi/d), NIOSH assumed a daily urine excretion rate of 1,400 milliliters per day (mL/d).

[1] Nuclear Metals Inc. was incorporated in 1954 and took over for work already occurring at the Massachusetts Institute of Technology's Metallurgical Laboratory. These earlier years (i.e., prior to 1958) are covered under a different Energy Employees Occupational Illness Compensation Program Act site titled "The Hood Building."

In order to account for workers who may have had a large number of bioassay samples in a given year due to incidents, NIOSH used the one-person, one-statistic technique as prescribed in ORAUT-RPRT-0053, revision 02 (ORAUT, 2014). NIOSH considered results of 1 microgram per liter (µg/L) prior to October 14, 1994, to be censored. NIOSH excluded two high results from the analysis. One was inconsistent with subsequent results for the same individual, and the other was noted in the records as being an error.

3.1 SC&A comments on bioassay data selection

SC&A agrees that duplicate bioassay results should be excluded from the data set used to create the internal co-exposure model. SC&A also believes that the methods NIOSH used to identify duplicate results is reasonable yet could be described more fully. NIOSH states that project health physicists reviewed the duplicate samples and performed "'fuzzy matching' techniques" (ORAUT, 2013, pp. 6–7). It would be helpful if OTIB-0084 provided additional details about how duplicates were identified and whether resample events (more than one result for an individual on a given date) were retained in the data.

SC&A reviewed the bioassay data compiled by NIOSH and found that there were limited bioassay data prior to 1978, with the exception of 1957 and 1958, which had 110 results and 149 results, respectively. SC&A also found that the only data beyond the year 2000 were 15 samples from 2011.

SC&A agrees with NIOSH's approach to use the one-person, one-statistic technique for analyzing the data. SC&A reviewed the high bioassay result NIOSH excluded and agrees with NIOSH's conclusion that the other bioassay results for this individual from the same time period are inconsistent with the high result.

Observation 1: Unable to locate erroneous high bioassay result in the dosimetry records

SC&A reviewed the bioassay records compiled by NIOSH and was unable to locate the high result that NIOSH stated was noted as an error in the records. SC&A requests additional information for this sample.

Observation 2: How to assign intakes prior to 1978

The language of OTIB-0084 indicates that the uranium intake rates should be assigned only for the years 1978 and later. SC&A questions how intakes should be assigned for unmonitored workers whose employment precedes 1978. While SC&A agrees that NIOSH has limited bioassay data prior to 1978, the potential for internal exposures exists based on available bioassay records as early as 1954. A comparison of the limited bioassay data outside the evaluated co-exposure period might inform as to whether appropriate extrapolation of co-exposure intakes or some other method of reconstructing unmonitored doses to natural and depleted uranium could be justified.

Observation 3: Reasoning for calculating intakes after 1990 if the NMI TBD instructs dose reconstructors not to use these values

Section 4.0 of the NMI technical basis document (TBD) DCAS-TKBS-0010, revision 00 (NIOSH, 2015), states that the intakes in OTIB-0084 should not be used after the year 1990, as intakes after this date are primarily from commercial work, which is not covered by the residual

period (i.e., urinalysis from the residual period would not necessarily reflect intakes of the post-operational contamination that may have been present). Internal dose estimates for the residual period are discussed in the NMI TBD. SC&A questions why the intakes past 1990 were calculated in OTIB-0084 if they are not to be used in dose reconstructions, and that OTIB-0084 does not provide specific guidance for the residual period.

Observation 4: NIOSH may not have used all available data in the analyses

SC&A questions whether NIOSH included all available bioassay records in the analysis. OTIB-0084 table A-1 lists the worker urinalysis sampling frequency by year from 1978 through 2000 for the data compiled by NIOSH. There is a noticeable difference in the number of employees accounted for in this table for the years 1979, 1993, and 1997, as shown in table 1 of this report. As stated in OTIB-0084, urinalysis frequency at NMI increased after 1978 due to a large contract to supply depleted uranium. Therefore, it seems reasonable to assume that bioassay records for more than 19 workers would exist for the year 1979. Additionally, SC&A reviewed a Site Research Database (SRDB) file that contains urinalysis records from 1992 to 1994 (NMI, 1992–1994) that do not appear to be included in the data NIOSH used in their analyses.

Table 1. Number of workers per year in NIOSH's analyses

Year	Number of workers
1978	132
1979	19
1980	417
1981	656
1982	863
1983	747
1984	679
1985	674
1986	583
1987	627
1988	556
1989	166
1990	473
1991	406
1992	389
1993	11
1994	167
1995	173
1996	209
1997	2
1998	97
1999	102
2000	33

Observation 5: Reiterating observation 1 from PER-070 review, regarding specific activity for uranium

In February 2024, SC&A reviewed DCAS-PER-070 for NMI (SC&A, 2024). In that document, SC&A's observation 1 called attention to the fact that a specific activity for depleted uranium was used in OTIB-0084, but the NMI TBD states a specific activity for natural uranium should

be used when converting urinalysis data to activity units. SC&A is reiterating this discrepancy in this review of OTIB-0084.

Observation 6: No rationale given for cutoff date of October 14, 1994, for assuming reported results are censored

NIOSH stated that bioassay results of 1 µg/L prior to October 14, 1994, are considered censored. However, OTIB-0084 does not contain the rationale for using October 14, 1994, as the cutoff date for this determination. SC&A reviewed available bioassay records and believes this may be the date after which bioassay results lower than 1 µg/L were reported; however, it is unclear if this is the case. SC&A believes OTIB-0084 would benefit from a discussion regarding why October 14, 1994, was chosen.

4 Intake Modeling and Assignment of Doses

NIOSH used the Integrated Modules for Bioassay Analysis (IMBA) program to fit the bioassay data for each radionuclide as a series of chronic inhalation intakes. NIOSH assumed all uranium activity was due to uranium-234 as a claimant-favorable measure. NIOSH separated the bioassay data into three different time periods, based on observed changes in the bioassay results. These time periods were 1978 through 1983, 1984 through 1994, and 1995 through 2000. For type S uranium, NIOSH modeled the intake for each time period independently, to avoid potential underestimation of intakes. OTIB-0084 states that this approach was not used for types F and M uranium. NIOSH calculated the 50th and 84th percentile excretion rates for each year and then modeled intakes in IMBA to fit the excretion rates for types F, M, and S uranium.

OTIB-0084 tables 5-1 through 5-3 list NIOSH's modeled 50th percentile and 95th percentile uranium intake rates in pCi/d for each time period, for types F, M, and S uranium, and the associated geometric standard deviations. A minimum geometric standard deviation of 3 was used to account for biological variation and uncertainty in the models. NIOSH states that the 95th percentile intakes should be assigned if it can be justified that the individual might have had larger intakes than the 50th percentile rates.

4.1 SC&A comments on intake modeling and assignment of doses

SC&A reviewed figures A-1 through A-12 of OTIB-0084 and concurs with the following NIOSH modeling methods:

- use of a chronic exposure pattern to approximate a series of acute intakes with unknown intake dates
- use of a 5-micrometer activity median aerodynamic diameter particle size distribution
- assumption that activity was from uranium-234 for IMBA modeling is claimant favorable
- assumption that solubility types F, M, and S could be present and should be evaluated

SC&A reviewed the uranium bioassay data and found that NIOSH's evaluation of the bioassay patterns and the use of three chronic intake periods for 1978–2000 are reasonable. The predicted bioassay results of the intakes NIOSH modeled for types F, M, and S uranium (shown in figures A-11 and A-12) appear to be claimant favorable when compared to the 50th percentile

and 84th percentile bioassay data. SC&A modeled intakes for types F, M, and S uranium using IMBA, and the resulting intake rates were reasonably similar to those calculated by NIOSH. SC&A also agrees that the 95th percentile intakes should be assigned for individuals that have the potential for intakes greater than the 50th percentile rates.

Observation 7: OTIB-0084 makes reference to multiple radionuclides, yet only discusses uranium

In section 3.1 of OTIB-0084, NIOSH states that bioassay records for radionuclides other than uranium were excluded from the analysis. However, in sections 3.2, 4.2, and 5.0, NIOSH makes reference to analyses for "each radionuclide" (ORAUT, 2013, pp. 7–9). SC&A requests additional information on what other nuclides NMI workers were bioassayed for, and why an internal co-exposure model was not developed for nuclides other than uranium.

5 Conclusions

SC&A reviewed the uranium bioassay data NIOSH collected, as well as the methods used to determine the co-exposure intakes for NMI workers. SC&A had no findings for OTIB-0084 but did have the following six observations:

- Observation 1: Unable to locate erroneous high bioassay result in the dosimetry records
- Observation 2: How to assign intakes prior to 1978
- Observation 3: Reasoning for calculating intakes after 1990 if the NMI TBD instructs dose reconstructors not to use these values
- Observation 4: NIOSH may not have used all available data in the analyses
- Observation 5: Reiterating Observation 1 from PER-070 review, regarding specific activity for uranium
- Observation 6: No rationale given for cutoff date of October 14, 1994, for assuming reported results are censored
- Observation 7: OTIB-0084 makes reference to multiple radionuclides, yet only discusses uranium

6 References

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