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Abbreviations and Acronyms

| | |
|--------------|--|
| ABRWH, Board | Advisory Board on Radiation and Worker Health |
| EEOICPA | Energy Employees Occupational Illness Compensation Program Act of 2000 |
| GSD | geometric standard deviation |
| IDOT | Internal Dosimetry Tool |
| IMBA | Integrated Modules for Bioassay Analysis |
| NIOSH | National Institute for Occupational Safety and Health |
| ORAUT | Oak Ridge Associated Universities Team |
| ORNL, X-10 | Oak Ridge National Laboratory |
| Pu | plutonium |
| PUREX | plutonium-uranium extraction |
| REDOX | reduction-oxidation |
| SEC | Special Exposure Cohort |
| SPR | Subcommittee for Procedure Reviews |
| Sr-90 | strontium-90 |
| SRS | Savannah River Site |
| THOREX | thorium extraction |

1 Introduction and Background

This report presents a focused review of “Internal Dosimetry Co-Exposure Data for Oak Ridge National Laboratory,” ORAUT-OTIB-0034, revision 04, dated September 1, 2020 (ORAUT, 2020a; “OTIB-0034”), as directed by the Advisory Board on Radiation and Worker Health (Board) on July 28, 2025. The purpose of OTIB-0034 is to provide guidance on the calculation and assignment of co-exposure intakes based on data from workers with similar exposure potential from Oak Ridge National Laboratory (ORNL, also known as X-10) for estimation of unmonitored exposures. SC&A notes that revision 04 changed the document title from “Internal Dosimetry Coworker Data for X-10” to “Internal Dosimetry Co-Exposure Data for Oak Ridge National Laboratory” for consistency with the U.S. Department of Energy site name and to accurately describe the coworker model as a co-exposure model.

This review principally addresses those changes that were introduced subsequent to previous SC&A reviews. As such, this review supplements SC&A’s previous draft reviews (SC&A, 2007, 2013) of OTIB-0034, revision 00 (ORAUT, 2005), submitted on October 29, 2007, and of OTIB-0034, revision 01 (ORAUT, 2013), submitted on November 20, 2013. According to the document publication record, revision 04 “constitutes a total rewrite of the document” and incorporates the “potential and intake rates for type SS plutonium,” also known as type SS or Super Slow plutonium (ORAUT, 2020a, p. 2).

2 Review History and Current Status

SC&A’s previous review (SC&A, 2007) of OTIB-0034, revision 00 (ORAUT, 2005), identified four findings. These findings were discussed during several Subcommittee for Procedure Reviews (SPR) meetings held June 9, 2009; November 7, 2013; February 13, 2014; and August 28, 2014. A summary of these findings is provided as follows. These findings were all found to be resolved by the SPR and are considered closed.

- Finding OTIB-0034-01: The procedure is not complete in terms of required data. The document references and uses data and procedures from other documents that need to be known in order to understand the procedures described in OTIB-0034.
- Finding OTIB-0034-02: The procedure points out that “a chronic exposure pattern was assumed” (ORAUT, 2005, p. 7). This may not be claimant favorable in many cases at ORNL (X-10), considering the fact that numerous buildings exist on the site where exact dates of operations are not known, and the site depended on area health physicists to determine if in-vivo monitoring should be done. Thus, identification of the workers to apply coworker models to is difficult, if not impossible.
- Finding OTIB-0034-03: For plutonium type S, the chronic intake for the entire set of years was fitted to the bioassay data for the last 3 years (1986 through 1988) and all the previous years of much higher values were ignored. It appears that the authors have selectively chosen the 50th percentile bioassay results for only the last 3 years and ignored all the previous data that are greatly elevated over these values to derive the inhalation intake model for the type S plutonium-239 (Pu-239). This does not provide a claimant-favorable model for reconstruction of doses.

- Finding OTIB-0034-04: The assumed and predicted intake fits versus the values in the first approximately 5 years are much less, and from about 3,800 days to 7,200 days; the model fit is much higher, indicating that the percentile used for deriving the intake should be greater. This would, in turn, be more claimant favorable.

SC&A's previous review (SC&A, 2013) of OTIB-0034, rev. 01 (ORAUT, 2013), also identified four findings. Although these findings (SC&A, 2013) were labeled as 1 through 4, some transcripts and documentation refer to the same findings as numbered 5 through 8, a continuation of numbering from the previous review (SC&A, 2007). These findings were discussed during Procedures Review Subcommittee meetings held on April 16, 2014, and August 28, 2014:

- Finding 1 (OTIB-0034-05): ORAUT-OTIB-0034 Fails to Mention/Address Potential Exposure to Pu-239 Type SS in its Coworker Model
- Finding 2 (OTIB-0034-06): Three of the Six Values for the 95th Percentile Intake of Pu-239 Type S in Table 5-5 of ORAUT-OTIB-0034 are Significantly Lower than Values Derived by SC&A and Should Be Reassessed
- Finding 3 (OTIB-0034-07): For the X-10 Internal Coworker Model (as well as other internal coworker models), Guidance for the Assignment of the 95th Percentile Intake Values to Unmonitored Workers is Currently Inadequate
- Finding 4 (OTIB-0034-08): [National Institute for Occupational Safety and Health's] NIOSH's Assumption of ORNL Bioassay Data as Representative of a Full Day (24 hours) of Urinary Excretion is Subject to Question

Findings 1, 2, and 4 were found to be resolved and were closed by the SPR. Finding 3 was placed in abeyance after wording was agreed upon to be included in an implementation guide, which was in draft form at the time. After lengthy discussion with the Special Exposures Cohort (SEC) Issues Work Group, DCAS-IG-006, revision 00, was issued on March 6, 2020 (DCAS, 2020; "IG-006"). SC&A confirmed that the agreed upon text on using the 95th percentile was included in the revision. SC&A recommends that finding 3 be changed from in abeyance to closed. It is SC&A's understanding that future revisions of the co-exposure model will address the tenets described in IG-006, which will further address data completeness, data adequacy, representation of the exposed workforce, and a discussion of possible stratification. These discussions are ongoing with the ORNL Work Group and an updated co-exposure is likely in process.

Additionally, due to the timing of SC&A's previous review (SC&A, 2013) of OTIB-0034, revision 01 (ORAUT, 2013); subsequent SPR discussions; and the issuance of OTIB-0034, revision 02 (ORAUT, 2014a), some of the changes incorporated in revision 02, including the values identified in finding 2, were evaluated as part of the issues resolution process with the SPR.

3 Changes to Revision

According to the document publication record, OTIB-0034, revision 04 “constitutes a total rewrite of the document” and incorporates the “potential and intake rates for type SS plutonium” (ORAUT, 2020a, p. 2). Despite this statement, SC&A did a direct comparison of the documents and found that the vast majority of the guidance in revision 04 remains unchanged with the exception of several key modifications outlined in the subsequent subsections. SC&A notes that, since revision 01 was the last revision reviewed, SC&A also assessed changes that occurred in subsequent revisions and remain in revision 04.

In reviewing revision 04, SC&A found that no co-exposure model values changed beyond the inclusion of Super S plutonium. Since the previous SC&A reviews evaluated the co-exposure modelling and no changes were identified, the modeling methods were not evaluated again. As stated in section 2, it is SC&A’s understanding that NIOSH is working on an updated co-exposure framework beyond the updated inclusion of Super S plutonium.

3.1 Type Super S plutonium

Historical studies have shown that, in some instances, the rate of removal of plutonium from the lungs was slower than predicted by type S (i.e., organ doses over time were underpredicted using type S absorption). This phenomenon is known as type SS. The biokinetic model to evaluate the deposition, retention, and removal of inhaled very insoluble type SS within the Energy Employees Occupational Illness Compensation Program Act of 2000 (EEOICPA) is discussed in ORAUT-OTIB-0049, revision 02 (ORAUT, 2020b; “OTIB-0049”). The previous revisions of OTIB-0049 that SC&A reviewed did not include guidance for type SS plutonium and instead just indicated it should be considered.

OTIB-0034, revision 04, adds a new table 6-8 to include a co-exposure model for type SS plutonium. For bioassay modeling, NIOSH assumes that all the alpha emitting isotopes of plutonium are Pu-239. Figures A-28 through A-31 in revision 04, attachment A, were also added, which show the fits for type SS material corresponding to each of the subsets of years across the intake period. A composite of the subsets of selected years used to fit the 50th percentile intake values for type SS plutonium is shown in figure A-32. SC&A reviewed these figures and found the modeled fit to be reasonable in all cases. SC&A notes that the figures visually appear different than the other figures in the document because they were modeled using Internal Dosimetry Tool (IDOT), rather than the Integrated Modules for Bioassay Analysis (IMBA). IDOT was evaluated by the Board as part of the 2021 review of OTIB-0049, revision 02, and approved for use when modeling type SS intakes and doses. Although stylistically different, they represent the same techniques used to model the other co-exposure models in OTIB-0034.

Table A-12 summarizes the intake period and rate for the 50th and 84th percentile values along with the geometric standard deviations (GSDs) for type SS plutonium. Consistent with the method used throughout OTIB-0034, NIOSH determined GSDs by dividing the 84th percentile intake rates by the 50th percentile intake rates. SC&A independently confirmed these calculations.

3.2 Additional radionuclides

In the previous OTIB-0034 revisions reviewed by SC&A (revisions 00 and 01), ORNL air monitoring perimeter data was used to develop the ratios of the isotopic concentration ratios of other radionuclides to the concentration ratio of strontium-90 (Sr-90). Current guidance now instructs:

dose reconstructors should use the intake mixture ratios in the latest revision of ORAUT-OTIB-0054, *Fission and Activation Product Assignment for Internal Dose-Related Gross Beta and Gross Gamma Analyses* [ORAUT, 2014b; “OTIB-0054”]. ORAUT-OTIB-0054 is applicable for workers in the Reactor Division and the Tank Farms areas. It should not be used for workers from the Isotopes Separations Division or Isotope Development Center (Buildings 3030 to 3047). [ORAUT, 2020a, p. 11]

SC&A agrees that it is more appropriate to use OTIB-0054 for fission and activation product mixtures for the Reactor Division than perimeter air monitoring data. SC&A questions the applicability of OTIB-0054 to the Tank Farms area.

Finding 1: SC&A questions the applicability of OTIB-0054 to the Tank Farms area

According to OTIB-0054, revision 02, “It [OTIB-0054 guidance] also does not apply to determination of intakes if radionuclides have been purposely extracted and concentrated, as for heat generation sources, medical uses, or waste handling operations that caused significant alteration to the source term to which workers were exposed” (ORAUT, 2014b, p. 7). The Tank Farms accepted and stored waste from chemical separations operations. These operations involved research on the bismuth-phosphate, reduction-oxidation (REDOX), plutonium-uranium extraction (PUREX), thorium extraction (THOREX), and fluoride chemical processes. Other research involved isolating americium and curium from irradiated fuels. All of these processes are designed to alter the source term, thus impacting the representativeness of the OTIB-0054 data on the waste being stored.

It should be noted that OTIB-0054 has been revised twice since 2014; however, the quoted statement has not changed.

In addition, SC&A notes that recent dose reconstruction white papers have been released involving exotic radionuclides. Most notably in “Monitoring Feasibility Evaluation for Exotic Radionuclides Produced by the Oak Ridge National Laboratory Isotopes Division,” ORAUT-RPRT-0090, revision 01 (ORAUT, 2023), which has an in-depth discussion of the source terms experienced and monitoring capability (i.e., data adequacy) at ORNL and is currently under discussion by the ORNL Work Group. As an ongoing discussion, SC&A believes these specific topics are beyond the purview of this specific review of OTIB-0034.

3.3 Nomenclature changes

A smaller change that appeared in OTIB-0034, revision 04, is the change from using the word “coworker” to the word “co-exposure.” This change is being made to all EEOICPA documentation and reflects a change in nomenclature that NIOSH agreed to during the December 5, 2019, Savannah River Site (SRS) and SEC Issues Work Group joint meeting

(ABRWH, 2019). The change in name has no material difference in the doses assigned to workers.

SC&A also notes that the date ranges of the subsets of years across the intake period were modified. In earlier revisions of the document, some tables listed dates as generic year ranges, for example 1951–1953. In the current revision, these ranges have been expanded for clarity. So instead of 1951–1953, the new date range is January 1, 1951 through December 31, 1953. The expanded date range reduces ambiguity especially at the transition years.

4 Conclusions

This report presents a focused review of OTIB-0034, revision 04, (ORAUT, 2020a). The purpose of OTIB-0034 is to provide guidance on the calculation and assignment of co-exposure intakes based on data from workers with similar exposure potential from ORNL for estimation of unmonitored exposures. SC&A performed a direct comparison of revisions 01 and 04 and found that the vast majority of the guidance in revision 04 remains unchanged with the exception of adding guidance for the assessment of type SS plutonium and other changes outlined in sections 3.1 through 3.3. SC&A evaluated these additions and found the type SS modeling to be reasonable and consistent with the methodology for assessing other radionuclides addressed in OTIB-0034 and programmatic guidance documents. SC&A identified a single finding regarding the applicability of OTIB-0054 to the Tank Farms area. Assessment of exposure to exotic radionuclides¹ encountered mostly by the Isotopes Division continues to be assessed by NIOSH and the Board.

¹ Radionuclides other than uranium, plutonium, and americium and the contaminants identified by OTIB-0054.

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