Review of ORAUT-OTIB-0036, Revision 00, “Internal Coworker Bioassay Data for Portsmouth Gaseous Diffusion Plant"

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ORAUT-OTIB-0036 – Purpose of review

- NIOSH issued OTIB-0036, rev. 00, on July 29, 2005 (ORAUT, 2005)
- Provides information for assigning internal dose to Portsmouth Gaseous Diffusion Plant (PORTS) workers who have no or limited monitoring data
- Based on site coworker (CW) bioassay data (currently, nomenclature is “co-exposure” instead of coworker)
- November 16, 2023, SC&A tasked by the subcommittee to review ORAUT-OTIB-0036, rev. 00
- SC&A issued review of ORAUT-OTIB-0036 on May 29, 2024 (SC&A, 2024)

NIOSH's source of bioassay data

- Urinalysis table in PORTS site database "HR_prior_1993"
- Internal data for 1955–1988 – Contained in a table within the field "RES_Alpha"
- Reported data corresponded to individual gross alpha bioassay results in units of:
  - disintegrations per minute per 100 milliliters (dpm/100 ml)
  - total uranium in units of milligrams per liter of urine

PORTS bioassay data

- PORTS began enrichment operations in September 1954
- No gross alpha bioassay results before 1955 in database
- Intake modeling based on 1955 and later data
- Uranium intakes should be considered possible as early as September 1, 1954

SC&A's review of NIOSH's data source

- Reviewed urinalysis table in the PORTS site database "HR_prior_1993"
- Found that excretion data for 1955 through 1988 – Contained in table within the field "RES_Alpha"

NIOSH's use of gross alpha measurements

- Gross alpha measurements have approximately 30 percent nonzero values recorded
- Total uranium results have approximately 4 percent nonzero values
- NIOSH used gross alpha results in analysis because it was considered a more robust data set

NIOSH's analysis of individual urinalysis results for 1955–1988

- Effective bioassay date set equal to midpoint of analysis period
- Lognormal distribution assumed
- 50th and 84th percentiles calculated for each quarter (year for 1955), using method described in revision 00, ORAUT-OTIB-0019 (ORAUT, 2004b)
- Table A-1 in attachment A of OTIB-0036 lists results of the statistical analysis of the gross alpha bioassay results

NIOSH's intake modeling

- Integrated Modules for Bioassay Analysis (IMBA) program used to analyze bioassay data:
  - Results recorded as gross alphas. Assumed activity from uranium (U)-234 for IMBA modeling as this is claimant favorable.
  - Uranium at PORTS could be present as solubility types F, M, or S lung clearance rates. All three material types evaluated.

NIOSH's evaluation of bioassay results

- Examined data for patterns of potential intakes and divided intake periods into intervals that had similar results
  - Made a new chronic intake period if data indicated a significant sustained change
  - Divided 1955–1988 into four chronic intake periods:

    1/1/1955 to 12/31/1956

    1/1/1957 to 12/31/1958

    1/1/1959 to 6/30/1961

    7/1/1961 to 12/31/1988

NIOSH use of bioassay results

- Results used to fit potential intakes for types F and M U-234 in IMBA, for each time period, considering all bioassay data from 1955–1988
- Type S uranium has very long radiological and biological half-life
  - To avoid potential underestimation of intakes for energy employees who worked for relatively short periods, NIOSH fitted each of the four chronic intake periods of type S material independently, using only bioassay results from each single intake period
  - This allows overestimate of intakes for assumed type S exposures extending through multiple intake periods

NIOSH's results using four time periods

- Derived potential 50th and 84th percentile daily uranium intake values for types F, M, and S in units of dpm/day
- Derived geometric standard deviation (GSD) by dividing 84th percentile value by 50th percentile value
- Results in table 5-1 for type F, table 5-2 for type M, and table 5-3 for type S

NIOSH's evaluation of recycled uranium (RU) contaminants

- Uranium streams at PORTS potentially include:
  - Plutonium
  - Neptunium
  - Technetium
- Use ORAUT-TKBS-0015-5, rev. 00 (ORAUT, 2004a) to derive RU constituent intake values in relation to CW uranium intakes

NIOSH's dose assignment recommendations

- Use 50th-percentile intake rates to derive internal organ dose
- Derive annual organ doses for types F, M, and S solubility
- Use material type resulting in largest probability of causation (POC) for the organ of concern
- Factor in RU contaminants when determining the most claimant-favorable solubility type
- Use lognormal distribution in the IREP program
- Apply the annual dose in parameter one and the GSD in parameter two

NIOSH's attachment A: Table and types F and M IMBA fitting plots

- Table A-1: Summary of 1955 and quarterly 1956–1988 bioassay data (dpm/day) used to derive CW intake values
- Figures A-1 through A-4 contain results of 50th and 84th percentile IMBA fitting analysis of 1955–1988 bioassay data for types F and M uranium

NIOSH's attachment A: Type S IMBA fitting plots

- Figures A-5 through A-8:
  - 50th IMBA fittings analysis for type S uranium
  - Uses bioassay data for the four individual periods during 1955–1988
- Figures A-9 and A-10:
  - 50th and 84th percentile, respectively, urinary excretion rates of type S uranium from 1955 to 1988
  - Predicted intake values based on four independent intake periods and their respective bioassay data

SC&A's review of ORAUT-OTIB-0036

- SC&A reviewed:
  - Original recorded PORTS bioassay data
  - NIOSH's accompanying calculation and analysis spreadsheets
- SC&A evaluated:
  - NIOSH's analysis of the bioassay data and recommendations
  - NIOSH's use of their analysis in constructing intake tables in OTIB-0036

SC&A's evaluation of NIOSH's analysis of individual urinalysis results

- Concur with use of gross alpha measurements for developing CW model:
  - Both data sets contained approximately 150,000 bioassay results
  - Present CW modeling would likely compare the results of both data sets
- Concur with grouping of bioassay data by quarterly intake periods for years 1956 through 1988:
  - Large number of bioassay results
  - Fewer numbers of bioassay samples in 1955, so all results were analyzed for the entire year
- No issues identified with entries in table A-1 of OTIB-0036

SC&A's evaluation of NIOSH's intake modeling

- Concur with modeling methods:
  - Using 1955 yearly and 1956–1988 quarterly data to fit a series of chronic intakes resulting in four distinct chronic intake periods
  - Assumed activity was from U-234 for IMBA modeling because claimant favorable:
    - Effective dose coefficient for U-234 is greater than for U-235, U-236, or U-238 per ICRP Publication 68 (ICRP, 1994; p. 68)
  - Solubility types F, M, and S could be present and should be evaluated
- Concur with designation and use of four chronic intake periods
- Concur with using bioassay data for each of the four periods in fitting the potential intakes for types F and M uranium, and four independent periods for type S uranium

SC&A's evaluation of NIOSH's methods used to derive CW intake values

- Analyzed database and spreadsheets used to derive CW intake values in tables A-1, 4-1, 4-2, 4-3, 5-1, 5-2, and 5-3
- Appendix A of SC&A's report (SC&A, 2024) summarizes SC&A's evaluation of methods NIOSH used to derive CW intake values
- SC&A concurs with NIOSH's methodology and derived intake values and has no findings or observations

SC&A's evaluation of NIOSH including RU contaminants

- Concur that RU contaminants should be accounted per PORTS site profile, ORAUT-TKBS-0015-5 (ORAUT, 2004a), using CW uranium intakes considering:
  - Lower solubility materials remain in lungs for longer periods, while higher solubility materials are transferred to systemic organs
  - Must compare annual doses on a case-by-case basis to determine which will deliver larger dose to the organ of interest
  - When RU contaminants are included, highest solubility types for each radionuclide is to be used

SC&A's evaluation of NIOSH's dose assignment recommendations

- Concur with 50th-percentile intake rates to be used to derive types F, M, and S U-234 annual internal organ doses
- Annual doses that result in largest POC for the organ of concern should be assigned with corresponding GSD
- RU contaminants should be included in determining the most claimant-favorable solubility type

SC&A's evaluation of NIOSH's IMBA fitting plots

- Reviewed and analyzed a select number of the IMBA runs as depicted in attachment A of OTIB-0036
  - Did not identify any issues
  - Found fitting plots helpful in following NIOSH's overall analysis of the bioassay data

SC&A's evaluation of NIOSH's use of bioassay data for constructing tables in OTIB-0036

- Reviewed entries in the tables of OTIB-0036 in view of SC&A's evaluation of NIOSH's data analysis
  - Did not identify any issues with the entries
  - SC&A does have the following observation

Observation 1: NIOSH did not use the 1989–1991 bioassay data

- PORTS site database "HR_prior_1993" contains recorded bioassay results for the period 1989–1991, as well as for 1955–1988, with some positive bioassay results recorded during all years
- NIOSH developed CW internal intake values for 1955–1988 but not for 1989–1991
- SC&A requests that NIOSH clarify why they did not analyze the later data to developed CW internal intake values for 1989–1991

Conclusions

- SC&A reviewed and evaluated:
  - Original recorded PORTS bioassay data
  - NIOSH's analysis of the data and recommendations
  - NIOSH's use of the data in constructing tables in OTIB-0036 for assigning CW uranium intakes
- CW modeling methods have changed since the issuance of OTIB-0036, but this document appears to be the current document for use in PORTS CW dose assignments
- SC&A identified no findings but did have one observation:
  - Observation 1: NIOSH did not develop a CW model using 1989–1991 bioassay results

Questions ?

References

International Commission on Radiological Protection. (1994). Dose coefficients for intakes of radionuclides by workers (Publication 68). *Ann. ICRP, 24*(4). SRDB Ref. ID 22731

Oak Ridge Associated Universities Team. (2004a). *Technical basis document for Portsmouth Gaseous Diffusion Plant – Occupational internal dose* (ORAUT-TKBS-0015-5, rev. 00). SRDB Ref. ID 20167

Oak Ridge Associated Universities Team. (2004b). *Technical information bulletin – Analysis of coworker bioassay data for internal dose assignment* (ORAUT-OTIB-0019, rev. 00). SRDB Ref. ID 19439

Oak Ridge Associated Universities Team. (2005). *Internal dosimetry coworker data for Portsmouth Gaseous Diffusion Plant* (ORAUT-OTIB-0036, rev. 00). SRDB Ref. ID 19463

SC&A, Inc. (2024). *A review of ORAUT-OTIB-0036 for internal coworker bioassay data for the Portsmouth Gaseous Diffusion Plant* (SCA-TR-2024-PR036 rev. 0). https://www.cdc.gov/niosh/ocas/pdfs/tibs/or-t36-r0.pdf