
Draft

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National Institute for Occupational Safety and Health

Review of ORAUT-TKBS-0020, Revision 00

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Abbreviations and Acronyms

ABRWH	Advisory Board on Radiation and Worker Health
AEC	Atomic Energy Commission
DR	dose reconstruction
m/s	meters per second
mrem	millirem
NIOSH	National Institute for Occupational Safety and Health
ORAUT	Oak Ridge Associated Universities Team
pCi/d	picocuries per day
pCi/m ³	picocuries per cubic meter
SEC	Special Exposure Cohort
TBD	technical basis document
TVA	Tennessee Valley Authority

1 Statement of Purpose

To support dose reconstruction (DR), 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-TKBS-0020, revision 00, “Technical Basis Document: Basis for the Development of an Exposure Matrix for Tennessee Valley Authority, Muscle Shoals, Alabama, Period of Operation: 1951–1955” (ORAUT, 2004; “TKBS-0020”). TKBS-0020 provides guidance for assigning occupational external and internal doses to employees at the Tennessee Valley Authority (TVA) in Muscle Shoals, Alabama.

In July 2025, SC&A was tasked by the Advisory Board on Radiation and Worker Health’s Subcommittee for Procedure Reviews to review TKBS-0020.

2 Background

TVA had a cooperative agreement with the Atomic Energy Commission (AEC) to research uranium recovery as part of fertilizer production from phosphate ore. This research and development took place from 1951 to 1955 within some buildings on the TVA site. The uranium recovery involved a process that was originally developed by Dow Chemical Company in Walnut Creek, California. The resulting uranium, in the form of uranium tetrafluoride, was dried and shipped to the AEC for further processing. An estimated 5.5 pounds of uranium concentrate was produced during the 1951–1955 timeframe and averaged 2 percent uranium by weight. Because no monitoring records were found for TVA, NIOSH estimated internal and external exposures using the Blockson Chemical Company exposure matrix (ORAUT, 2003a). Blockson Chemical Company produced 50,000 pounds of uranium oxide per year; therefore, NIOSH scaled the exposures for TVA accordingly.

3 Internal Exposure

NIOSH compared the production rate of uranium at Blockson Chemical Company to the estimated production rate of uranium at TVA and determined that the uranium inhalation potential at TVA was a factor of 45,300 lower than at Blockson Chemical Company. NIOSH used the calculated median intake rate of 24 picocuries per day (pCi/d) from Blockson Chemical Company and an assumed 8-hour workday to calculate an estimated air concentration of 2.5 picocuries per cubic meter (pCi/m³) for Blockson Chemical Company. NIOSH then reduced this air concentration by the factor of 45,300, resulting in an intake rate of 5.3E-04 pCi/d and air concentration of 5.5E-05 pCi/m³ for TVA. A continuous exposure at this concentration for the entire 5 years TVA was active would only result in a total inhalation intake of 1 picocurie. Therefore, NIOSH does not include inhalation intakes in DRs for TVA. NIOSH also determined that the ingestion of uranium, based on the assumed air concentration to be 1.1E-05 pCi/d. NIOSH stated that this intake was also insignificant and therefore does not include ingestion in DRs for TVA.

3.1 SC&A comments on internal exposure

SC&A reviewed ORAUT-TKBS-0002, rev. 00, the technical basis document (TBD) for Blockson Chemical Company (ORAUT, 2003a) and agrees with NIOSH's determination that similar work was done at TVA. SC&A believes that scaling the intakes from Blockson Chemical Company according to the amounts of uranium produced at TVA is also appropriate, given that only a small amount of uranium was produced at TVA. SC&A agrees with NIOSH's determination that inhalation and ingestion intakes do not need to be included in DRs, as the estimated intakes were very low.

For completeness, SC&A also reviewed the most recent version of DCAS-TKBS-0002, revision 04 (NIOSH, 2014). The intakes calculated for the building where the uranium recovery took place remained the same and assumed administrative workers were exposed to the median concentration, while production workers were exposed to the 95th percentile concentration. Given NIOSH's reasoning that the uranium operations at TVA were more research based than production based like at Blockson Chemical Company, SC&A believes that using the median concentration for estimating TVA intakes is still appropriate.

Observation 1: Updates to Blockson Chemical Company TBD may affect TVA estimates

For Blockson Chemical Company, SC&A reviewed OCAS-PER-020 in 2009 (SC&A, 2009), the petition evaluation report for Special Exposure Cohort (SEC) petition SEC-00225 in 2016 (SC&A, 2016), and DCAS-PER-036 in 2024 (SC&A, 2024). SC&A notes that if the resolution of any findings or observations from these reviews affects the estimates for TVA, TKBS-0020 should be revised accordingly.

4 Radon Exposure

In TKBS-0020, revision 00, this section was reserved.

4.1 SC&A comments on radon exposure

SC&A notes that this section was reserved for TVA, as it was for Blockson in ORAUT-TKBS-0002, revision 00.

Observation 2: Update radon exposure potential

In the most recent version of DCAS-TKBS-0002, revision 04 (NIOSH, 2014), NIOSH stated that as a result of the SEC determination, doses from radon exposure could not be reconstructed for Blockson Chemical Company during the operational period. SC&A requests additional information on whether radon exposure for TVA workers can be reconstructed.

5 External Exposure

The potential for external exposure at TVA is due to submersion in air contaminated with uranium dust, exposure from contaminated surfaces, exposure from skin contamination, exposure from drums containing uranium, and occupational medical exposure from x-rays. The radionuclides of interest for external exposure are uranium-238, thorium-234, and protactinium-234m.

To assess external exposure from submersion in air, NIOSH used the estimated uranium air concentration calculated for the internal dose estimate ($5.5E-05$ pCi/m³); dose coefficients for uranium-238, thorium-234, and protactinium-234m from Federal Guidance Report 12 (EPA, 1993); and an assumed 2,000-hour work year. Based on these assumptions, a derived annual organ dose estimate of less than 1 millirem (mrem) was calculated and therefore not included in the DRs.

NIOSH estimated the potential external exposure due to surface contamination by using the estimated air concentration, an indoor deposition velocity of 0.00075 meters per second (m/s), an assumed deposition time of 1 year, and the contaminated ground surface dose coefficients from Federal Guidance Report No. 12. Since the cumulative dose for the 1951 through 1955 period would be less than 1 mrem, external dose from surface contamination is not included in DRs.

To estimate the external dose due to skin contamination, NIOSH used a deposition velocity to skin of 0.012 m/s; a deposition time of 8 hours for one shift; and electron dose rate conversion factors for uranium-238, thorium-234, and protactinium-234m for skin in contact with radionuclides. It was assumed that skin contamination accumulated at the beginning of the shift and the employee then showered at the end of the shift. The annual dose to skin was assumed to be $1.9E-07$ rem; therefore, NIOSH does not include this dose in DRs.

To estimate the external exposure due to drums of uranium, NIOSH assumed that all 5.5 pounds of uranium produced at TVA were stored in one container. NIOSH compared dose rate measurements of a half-full container of uranium from Fernald containing approximately 1,500 pounds of uranium to modeled dose rates using the computer codes MicroShield and MCNP from the Blockson Chemical Company TBD (ORAUT, 2003a). NIOSH used the dose rates from the Fernald drum of uranium as they were the most claimant favorable. NIOSH assumed the worker was 1 meter from the container for 1 hour of each workday, 5 days a week, for 50 weeks per year. The resulting annual external dose is 0.017 rem. This dose was then multiplied by the photon dose conversion factors for each organ.

NIOSH also assumed that each worker received a posterior-anterior occupational medical x-ray annually. Doses were calculated based on ORAUT-OTIB-0006, revision 02 (ORAUT, 2003b), which was current at the time TKBS-0020 was written.

5.1 SC&A comments on external exposure

SC&A reviewed NIOSH's methodology for estimating external exposure due to submersion in contaminated air and was able to closely match NIOSH's calculated annual organ doses. SC&A notes that the calculations assumed working 2,000 hours per year and do not appear to account for potential overtime worked. However, SC&A acknowledges that, even if the dose estimates were increased by 20 percent to account for overtime, they would still be insignificant in magnitude for DRs.

SC&A reviewed NIOSH's methodology for estimating external exposure due to surface contamination. SC&A believes that the deposition velocity selected by NIOSH is reasonable. SC&A was able to closely match NIOSH's calculated annual organ doses.

SC&A also reviewed NIOSH's calculations and assumptions for estimating external dose due to skin contamination. SC&A does question NIOSH's assumption that all workers showered and removed their work clothing at the end of their shift. However, modifying this assumption would have an insignificant impact on estimated doses associated with skin contamination.

Observation 3: Update methodology to Battelle-TBD-6000, revision 1

SC&A recognizes that TKBS-0020 was written prior to Battelle-TBD-6000, revision 1 (NIOSH, 2011; "TBD-6000"), but notes that, if TKBS-0020 were to be revised in the future, applicable dose estimate methodologies should be updated to utilize TBD-6000 for consistency across similar sites.

SC&A reviewed NIOSH's methodology for estimating external shallow dose due to skin contamination. SC&A believes NIOSH's assumption for the worker to be exposed during an 8-hour shift is reasonable considering that accounting for potential overtime would not have a significant impact on the dose.

SC&A reviewed NIOSH's methodology for estimating dose due to skin contamination. SC&A located the reference NIOSH used for the skin contamination dose rate conversion factors (Kocher and Eckerman, 1987) and used the conversion factors for a tissue depth of 7 milligrams per square centimeter. Assuming the air contamination was allowed to settle on the worker's skin during an 8-hour period, and that this contamination was cleaned off the skin at the end of each workday for 250 workdays per year, SC&A calculated an annual dose to the skin of 4.25E-05 rem.

Observation 4: SC&A could not match skin contamination dose calculated by NIOSH

Using NIOSH's stated assumptions and referenced document (TKBS-0020, page 6) for calculating skin dose due to contamination, SC&A calculated an annual dose of 4.25E-05 rem that is two orders of magnitude higher than NIOSH's dose estimate of 1.9E-07 rem. Although SC&A's calculated dose is still negligible, a resolution to this discrepancy should be sought.

SC&A reviewed NIOSH's methodology for estimating external dose due to drummed uranium. SC&A agrees that the dose rate from the drummed uranium at Fernald provided the most claimant-favorable dose estimate for TVA. SC&A was able to closely match NIOSH's calculated annual doses assuming the worker was 1 meter from the drum for 1 hour per day, 5 days per week, 50 weeks per year.

Observation 5: Justification needed for assumed time and distance spent near drum

SC&A reviewed ORAUT-TKBS-0002, revision 00, for Blockson Chemical Company (ORAUT, 2003a), which used the same Fernald dose-rate measurements to estimate external dose from drummed uranium. In that dose estimate, workers were assumed to be 1 foot from the drummed uranium for 8 hours per day, 1 day per week, and 50 weeks per year. SC&A requests more information on how NIOSH determined that TVA workers would be further away from the drummed uranium and how the length of time for the dose estimate was assumed.

6 Residual Radioactivity

NIOSH determined that there was very little potential for radioactive contamination at the facility beyond the operational period and does not include exposures due to residual radioactivity in DRs for TVA.

6.1 SC&A comments on residual radioactivity

SC&A agrees that there was very little potential for radioactive contamination at the facility after operations ended.

7 Conclusions

SC&A reviewed internal and external dose estimates developed by NIOSH for TVA. SC&A had five observations, as follows:

- Observation 1: Updates to Blockson Chemical Company TBD may affect TVA estimates
- Observation 2: Update radon exposure potential
- Observation 3: Update methodology to TBD-6000
- Observation 4: SC&A could not match the skin contamination dose calculated by NIOSH
- Observation 5: Justification needed for assumed time and distance spent near drum

8 References

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