Review of NIOSH's Program Evaluation Report DCAS-PER-075, "Battelle Memorial Institute TBD Revision"

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DCAS-PER-075 purpose

- Address the impacts of issuing rev. 01 of technical basis document (TBD) ORAUT-TKBS-0058 for Battelle Memorial Institute (BMI) on previously completed cases
  - Revision 01 issued as a result of Special Exposure Cohort (SEC) reviews

Battelle Memorial Institute (BMI) locations

King Avenue, Columbus, OH

- Processed and machined enriched, natural, and depleted uranium and thorium
- Fabricated fuel elements
- Analyzed radiochemicals
- Studied power metallurgy

West Jefferson, Columbus, OH

- Operated a large hot cell facility and a research reactor
- Reactor defueled and partially dismantled in 1975

Two classes of BMI workers added to the SEC

Petition 208: April 16, 1943, through June 30, 1956

- Not feasible to reconstruct internal doses for uranium, thorium, and progeny
- Not feasible to reconstruct external doses through February 13, 1951

Petition 229: July 1, 1956, through December 31, 1970

- Insufficient information to reconstruct internal exposures to thorium and progeny

BMI timeline

King Avenue

- **Covered period:**
  - **Atomic Weapons Employer (AWE):** 1943–1986
  - **DOE:** 1986–2000
- **Residual period:** 2001–March 1, 2011

West Jefferson

- **Covered period:**
  - **AWE:** 1956–1975
  - **DOE:** 1986–present
- **AWE residual period:** 1976–1985

Subtask 1: Changes necessitating PER

- As a result of SEC reviews, rev. 01 of ORAUT-TKBS-0058 was issued in June 2016
- Revision has the potential to increase dose due to:
  - Inclusion of environmental doses
  - Recycled uranium components
  - Other modifications to the internal and external dose assessment

Subtask 2: Assess corrective action methods

- SC&A has not previously reviewed ORAUT-TKBS-0058
- Therefore, SC&A's Subtask 2 review of PER-075 evaluates ORAUT-TKBS-0058 guidance on dose reconstruction (DR)

Occupational internal dose estimate

- In vitro and in vivo bioassay monitoring required at BMI
  - Urinalysis
  - Fecal analysis
  - Nose swabs/lapel sampling
  - Whole body counting
- Information for interpreting bioassay results for:
  - Plutonium
  - Fission products

Urinalysis

- Earliest record in 1956
- Frequency determined by workers' exposure potential
- Samples also collected after incidents
- TBD table 4-3 has urinalysis minimum detectable amounts (MDAs) over time
- Some samples from 1976 through 1982 marked "RU" for radiometric uranium
  - Gross activity measured, rather than mass or uranium in sample by fluoroscopy
  - May have been used to quantify exposures from enriched uranium
- If uranium enrichment unknown, assume natural uranium
- After 1952, recycled uranium assumed to be present at site
  - TBD includes contaminant activity fractions

Fecal analysis

- Records from May 1974 through March 1982
- Analyzed for K-40, uranium, plutonium, americium, and fission products
- Collected as needed after incidents

Nose swab and lapel sampling

- Nose swabs collected after incidents or when exiting dusty cleanup work in JN-4
- Lapel samplers used in JN-4 beginning in 1975
- Results from nose swabs and lapel samplers not used to quantify intakes, but used to verify if a worker had a positive intake after an incident

Whole-body counting

- Earliest record in August 1970
- For records prior to 1995, TBD lists max MDAs if MDA not listed with record
- After 1995, MDAs were reported with results

Plutonium

- TBD includes:
  - Assumed plutonium isotopic composition
  - Absorption types applicable for the site

Fission products

- TBD recommends using ORAUT-OTIB-0054 to reconstruct doses for workers with bioassay results reported as only gross beta or gamma
- NIOSH determined that workers were likely not exposed to radioiodine, as the areas where fission products were handled had adequate ventilation
- TBD also provides spent fuel cooling times to use with OTIB-0054

SC&A comments on internal dose: Urinalysis

- SC&A agrees with the assumption that recycled uranium was potentially processed at the site
  - Contaminant activity fractions in TBD matched those in Battelle-TBD-6000 (TBD-6000)
- SC&A had two observations regarding BMI urinalyses

Observation 1

SC&A unable to verify detection limits listed in TBD table 4-3

- SC&A was able to verify the detection limits for mixed fission products after 1993 and for isotopic uranium and isotopic plutonium after 1992
- SC&A reviewed several site records and was unable to verify the remaining detection limits in TBD table 4-3
- SC&A requests clarification on how the values in TBD table 4-3 were selected

Observation 2

Unclear how radiometric uranium analysis results should be interpreted for dose reconstructions

- TBD states that some urinalysis results designated as “RU” for “radiometric uranium” and that the detection limits for this analysis are unknown
- TBD does not provide guidance on how to assess “RU” results
- SC&A requests additional information on how the “RU” urinalysis results should be used in DRs if the detection limits are unknown

SC&A comments on internal dose: Fecal samples, nose swabs, and lapel sampling

- SC&A agrees with NIOSH's approach that results from these bioassay methods should be used to verify a potential positive intake

SC&A comments on internal dose: Fission products

- SC&A agrees with NIOSH's assumption that radioiodine does not need to be considered
  - Areas handling fission products had exhausts above the pool-type reactor, individual exhausts for the hot cells, building exhaust for the hot cell facility, and gloveboxes and hoods with exhausts and HEPA filters

Observation 3

Information needed for x-ray diffraction sample preparation methodology

- SC&A reviewed attachments B, C, and D of the TBD
- Footnotes in some tables in these attachments indicate that x-ray diffraction was performed on samples using powder samples, and that small amounts of the sample material should be assumed to have been ground into a powder
- Table B-1 indicates that grinding may have taken place in Building 5 (machine shop) of King Avenue location
- SC&A requests additional information about how samples were ground into powder, and what monitoring may have been conducted of the workers performing the grinding

Occupational external dose estimate

- TBD contains information about external dosimetry practices at BMI
- Per SEC Petition 208, it is not feasible to reconstruct external doses before February 13, 1951
- For some individuals, dose records may be missing for short periods of time
  - May be due to actual missing records or the worker had little exposure potential and was not monitored during that time

Beta dose

- From 1956 through 1961, beta exposures may have been reported as “other” or “arbitrary units”
- Dose converted using factors based on assumed beta energy
  - BMI records may include notes about the assumed beta energy, the multiplication factor to apply, or both
- TBD lists multiplication factors to use for “old” fission products, “new” fission products, and uranium
- If records do not indicate an assumed beta energy or multiplication factor, a factor of 5.3 is used as a claimant-favorable assumption

Photon dose

- TBD lists photon energy parameters for:
  - Natural/depleted uranium
  - Enriched uranium
  - Natural thorium
  - Mixed fission products
  - Plutonium
- If the specific materials a worker was exposed to cannot be determined, assume 100% 30–250 keV photons

Neutron dose

- Neutron exposures monitored via nuclear track emulsion, type A (NTA) film dosimeters at West Jefferson
  - To account for NTA film underresponse, NIOSH calculated neutron-to-photon (n/p) ratios derived using workplace measurements from site survey records
  - Prior to 1970, neutron surveys were reported in terms of thermal and fast neutron flux
  - NIOSH used an equation from NCRP Report 38 to calculate dose rates from reported neutron flux

Environmental dose

- Measurements of onsite external dose for West Jefferson site were collected from 1978 through 2005
  - No report found for 1999
- Environmental monitoring performed at King Avenue site from 1993 through 1998
- King Avenue measurements were lower than West Jefferson measurements; therefore, NIOSH applied West Jefferson measurements for both sites
- Assumed workers exposed 2,000 hours per year
- For years prior to 1978, the highest annual dose from 1978 through 2005 should be applied

SC&A comments on occupational external dose

- SC&A reviewed a sample of film badge dosimetry records from 1956 through 2008 and confirmed the various dosimetry processing services listed in TBD table 5-1
- SC&A was able to verify most of the minimum detection levels (MDLs) listed in TBD table 5-2, except for the periods listed in observation 4
- SC&A agrees with NIOSH's determination of the neutron dosimeter MDL for 1961 through 1996

Observation 4

SC&A is unable to verify several MDLs listed in TBD table 5-2

- Unable to verify the stated photon MDL of 50 mrem for March 1951 through March 1956
  - SC&A reviewed some monitoring records from 1951 and 1952 that reported doses of 30 mrem
  - SC&A requests further explanation for NIOSH's assumed photon MDL for this period
- From review of site film badge results from 1959 to 1964, SC&A is unable to verify the photon, beta, and neutron MDLs listed in the TBD
  - SC&A requests additional information from NIOSH about how those MDLs were determined

Observation 5

Clarification needed for workplace radiation fields

- NIOSH cited the external dose TBDs for Y-12, Lawrence Livermore National Laboratory, Idaho National Laboratory, and Los Alamos National Laboratory for the workplace radiation fields photon energy ranges in TBD table 5-4
- SC&A reviewed these TBDs and found potential inconsistencies in the assumed photon energy range percentages for natural uranium, depleted uranium, enriched uranium, and plutonium
- SC&A requests additional information on how NIOSH determined the energy range percentages assumed for BMI

SC&A comments on beta dose

- SC&A reviewed the references NIOSH cited for the beta multiplication factors and was able to confirm the factors given in the TBD
- SC&A finds NIOSH's guidance to use a factor of 5.3 when the dose record does not include a multiplication factor or beta energy to be claimant favorable and reasonable
- SC&A had one observation about interpreting these dosimetry records

Observation 6

Unclear if doses reported as "arbitrary units" would be reported on various dose records

- SC&A reviewed dose records from September 1956 that were reported on two different dosimetry forms
  - One form had a column labeled "other," and the second form did not have this column
  - Based on inconsistency between these forms, it is unclear how the beta dose would be interpreted
  - It is also unclear if any notes about the assumed beta energy or multiplication factor would appear on the forms lacking the "other" column

SC&A comments on n/p ratio

- SC&A reviewed attachment F of the TBD, which contains NIOSH's analyses for the n/p ratios
- SC&A also reviewed NCRP Report 38 and the equation NIOSH used to convert thermal and fast neutron flux to dose
- NIOSH provided SC&A with the spreadsheets containing the data and calculations
- SC&A has one observation regarding the n/p ratios

Observation 7

More information needed on what records were selected for n/p ratio calculations

- NIOSH stated that for the JN-1 and JN-4 n/p ratios, only a sampling of available records was used in the calculations
  - JN-1 calculation used 49 measurements
  - JN-4 calculation used 41 measurements
- SC&A requests additional information on how the records that were used were selected from the available data
- Additionally, it is unclear why NIOSH limited the data used for these calculations when over 2,000 measurements were used in the calculation of the JN-3 n/p ratio

Observation 8

TBD lacks guidance about glovebox workers in JN-1 and JN-3

- The last paragraph of TBD section 5.5 states that guidance in DCAS-TIB-0010 applies to glovebox workers handling plutonium in JN-2 and JN-4
- SC&A asks if this guidance also applies to glovebox workers in JN-1 and JN-3

SC&A comments on external ambient dose

- SC&A reviewed NIOSH's methodology for determining annual ambient external doses using the yearly site environmental reports
- SC&A believes that assigning the higher doses from perimeter measurements for 1985 through 2004 rather than lower doses from the recreation area and property boundary is reasonable and claimant favorable
- SC&A also agrees that applying the higher doses from the West Jefferson site to the King Avenue site is reasonable and claimant favorable
- SC&A has two observations about external ambient dose

Observation 9

SC&A requests additional information regarding the applicability of post-operational environmental monitoring data for pre-1978

- TBD states that for years prior to 1978, the highest annual dose from 1978 through 2005 should be applied
- The available environmental data are from the residual period and remediation period
- SC&A requests additional information on how NIOSH determined these data were representative of environmental data for pre-1978 operations

Observation 10

Ambient external dose does not account for potential overtime

- NIOSH assumed workers exposed 2,000 hours per year
- SC&A reviewed an employee interview from a past BMI DR audit that stated they worked up to 16 hours of overtime a week
- SC&A suggests that if workers routinely worked more than 40 hours per week, it would be appropriate to adjust the assumed worker occupancy accordingly
  - This also applies to environmental internal dose

Internal dose from onsite atmospheric radionuclides

- Stack sampling at King Avenue took place from 1973 through June 1975
- Stack sampling at West Jefferson took place from 1973 through 2005
- NIOSH used NCRP Report 123 methodology to estimate onsite atmospheric dispersion factor to calculate onsite atmospheric concentrations
- Inhalation intakes calculated using dispersion factor, breathing rate of 1.2 m^3/hr, and exposure of 2,000 hr/yr
  - **West Jefferson:** For years prior to 1973, assign highest intakes for alpha-emitters from 1993. For years prior to 1975, assign highest reported mixed fission product intakes from 1977.
  - **King Avenue:** Doses less than 1 mrem per year
- If a worker may have traveled between locations, the West Jefferson intakes should be applied

SC&A comments on internal dose from onsite atmospheric radionuclides

- SC&A reviewed attachment G of the TBD
- SC&A was able to closely match NIOSH's atmospheric dispersion factor and the calculated intakes in TBD tables G-1 and G-2
- As mentioned in observation 10, the intakes may need to be adjusted to account for potential overtime
- SC&A had two observations

Observation 11

Inconsistency in the application of external and internal environmental dose

- For external environmental dose, NIOSH states that dose estimated from West Jefferson data may also be applied to the King Avenue site
- However, for internal environmental dose, NIOSH states that West Jefferson data should be applied to King Avenue workers who may have traveled between sites, rather than applying it to all workers as was done for the external dose

Observation 12

Clarification needed on years with highest alpha-emitter and mixed fission and activation product environmental intake

- It appears that NIOSH chose the years 1993 and 1977 based on the highest sum of radionuclides for a given year, as shown in TBD figures 6-1 and 6-2
- If the ratio of the activity of the radionuclides remains fairly constant, then this would be claimant favorable and reasonable, but this does not appear to be the case
- Table G-1 for 1993 shows that U-238 is the driver, but Pu-239 and Am-241 decreased from 1992 to 1993
- Table G-2 shows Co-60 is the driver, but many other radionuclides vary by year
- Which radionuclide dominates depends upon the target organ
- SC&A believes more analysis may be warranted for NIOSH to demonstrate their recommendation is claimant favorable

Residual period exposure

- **West Jefferson:** 1976 through 1985
- **King Avenue:** 2001 through present
- NIOSH states workers at both sites were monitored for internal and external exposure during residual periods, no additional assessment needed to complete DRs for these periods

SC&A comments on residual period

- SC&A confirmed that BMI had the capability to conduct external monitoring for photons, betas, and neutrons for both residual periods
- SC&A also had one observation about the residual period

Observation 13

It is unclear what internal exposure monitoring capabilities existed for BMI after 1998

- It was not clear from SC&A's review of the internal dosimetry section of the TBD what internal dosimetry methods were available for BMI after 1998
- Tables 4-1 and 4-3 indicate urinalysis ended in 1998, and section 4.2 states that the latest in vivo analysis record was also from 1998

Occupational medical dose estimate

- Before 1957, x-rays performed offsite and are not eligible for inclusion in DRs
- Between 1957 and 1968, x-rays may have been performed onsite or offsite
  - NIOSH instructs dose reconstructors to assume onsite x-rays began in 1957 unless the claimant has offsite records during that time
- A machine described as radiographic and fluoroscopic was installed in 1968
  - NIOSH states no evidence of chest fluoroscopy and to assume only radiographic mode was used
- Starting in 1957, assume a preemployment, annual, and termination chest x-ray
  - Records indicate a lateral chest x-ray also performed annually from 1975 through 1980
- Occupational medical doses not reconstructed for residual periods
- Use ORAUT-OTIB-0006 for assigning organ doses

SC&A comments on occupational medical dose

- SC&A concurs with NIOSH that offsite x-rays are not eligible for inclusion in a DR
- SC&A also concurs with NIOSH's assumed x-ray frequency and the use of OTIB-0006 for assigning organ doses
- SC&A has one observation

Observation 14

Evidence of photofluorographic examinations at BMI

- As part of the 29th set of DR reviews, SC&A reviewed Tab 589, which involved a former BMI employee
- In that DR, NIOSH assigned dose from photofluorographic (PFG) examinations in 1960 and 1961
- SC&A requests more information regarding the potential use of PFG exams

Observation 15 (regarding overarching DR methodology guidance)

Inadequate dose reconstruction guidance for workers with potentially missing dose records

- TBD acknowledges that external monitoring records may be missing from a monitored worker's dosimetry files
- SC&A therefore assumes that all types of dosimetry records, including internal monitoring, might be similarly incomplete in some cases
  - TBD does not address potential missing internal monitoring records
- For potential gaps in external records, NIOSH recommends interpolating if the gap is small
- If the gap is more significant, alternate methods should be used
  - No further guidance given regarding alternative methods

Subtask 3: PER selection criteria

- All completed claims with verified employment at BMI
  - 91 claims
- 27 claims had a probability of causation (POC) greater than 50% and were removed from further evaluation
  - 64 claims
- 20 claims already used rev. 01 of the TBD, were awaiting a DR, or were pulled from DR and were removed from further evaluation
  - 44 claims
- Also searched DR reports for “Battelle” and identified 3,126 claims
  - 72 already identified. 3,050 claims had no connection to BMI
  - Remaining 4 claims added to initial search
- 12 claims were members of SEC and were removed from further evaluation
  - 36 claims

NIOSH's evaluation of impacted claims

- 31 of the 36 claims unaffected by changes in rev. 01 of the TBD
  - 5 claims reevaluated
  - 4 claims had POC less than 45%
  - 1 claim had POC between 45% and 50%
    - IREP run 30 times at 10,000 iterations, POC still below 50%
- SC&A agrees with NIOSH's selection criteria and that they are broad enough to capture all potentially affected claims
- PER was conducted in a timely manner
  - TBD revision 01 issued in June 2016, PER-075 issued in December 2017
- SC&A had two observations

Observation 16

Details needed on how four claims from the second search were not identified in the first search

- It is unclear from NIOSH's description of the selection criteria how the four claims from the second search were not found during the initial search of claims with BMI employment
- If these claims only involved visits to BMI, SC&A asks if other PERs include a step of searching all DR reports for mentions of a given site name

Observation 17

Information requested regarding NIOSH's determination that 31 claims were unaffected by BMI TBD changes in revision 01

- SC&A believes the changes in rev. 01 of the TBD have the potential to affect more than 5 out of 36 claims
- Since uranium was processed at the site, and urinalyses were analyzed for uranium 1957–1998, SC&A believes the potential for workers to have been exposed to uranium and therefore recycled uranium could have affected more than 5 out of 36 claims
- SC&A requests information for how NIOSH determined claims were not exposed to recycled uranium components

Subtask 4: Audit of reevaluated DRs

- SC&A recommends that the Board select the appropriate number of cases necessary to assess all changes introduced in revision 01 of the TBD:
  - Assignment of environmental internal dose
  - Assignment of environmental external dose
  - Assignment of recycled uranium components
  - Assessment of thorium intakes
  - Assessment of beta dose for records expressed in arbitrary units

Questions?