DCAS-PER-051, Subtask 4: Review of Three Advisory Board-Selected Cases Reworked for the Evaluation of DCAS-PER-051

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Weldon Spring site profile revisions that triggered PER-051

- Oak Ridge Associated Universities Team (ORAUT)-TKBS-0028-3 (TBD-3), occupational medical dose, rev. 01, issued January 30, 2013
- ORAUT-TKBS-0028-4 (TBD-4), occupational environmental dose, rev. 01, issued May 17, 2013
- ORAUT-TKBS-0028-5 (TBD-5), occupational internal dose, rev. 01, issued March 15, 2013; rev. 02, issued May 21, 2013
- ORAUT-TKBS-0028-6 (TBD-6), occupational external dose, rev. 01, issued February 6, 2013

Weldon Spring facilities

- Weldon Spring Plant (WSP), Weldon Spring Quarry (WSQ), and Weldon Spring Raffinate Pits (WSRP)
- Referred to as “Weldon Spring Plant” in general
- Operated by U.S. Atomic Energy Commission as a feed materials plant to process uranium and thorium ore by Uranium Division of Mallinckrodt Chemical Works

Four periods of site operations

1. **Site acquisition and development:** 1954–1957
2. **Operational:** 1957–1966
3. **Post-operational:** 1967–1985. U.S. Department of Defense, not U.S. Department of Energy, controlled:
   - WSP during post-operational period 1967–1985
   - WSRP and WSQ during 1967–1974
4. **Remediation:** 1985–2002

EEOICPA coverage

- WSP employment is covered:
  - Operational period (1957–1966)
  - Remediation period (1985–2002)
- WSQ and WSRP employment is covered:
  - Operational period (1957–1966)
  - Post-operational period (1975–1984)
  - Remediation period (1985–2002)

Radionuclides of dose significance

- Natural uranium (NU) processed 1957–1962
- After 1962, all uranium is assumed to be enriched to 1 percent
- Natural thorium
- Recycled uranium (RU) was processed beginning in 1961
- Radon-222 and radium-228 considered to be potentially significant for DR

DCAS-PER-051 issued and reviewed

- March 4, 2015: NIOSH issued PER-051
- February 16, 2023: Subcommittee for Procedure Reviews (SPR) tasked SC&A to review DCAS-PER-051, “Weldon Spring Plant”
- September 21, 2023: SC&A issued Subtasks 1-3 revision 1 of “A Review of NIOSH’s Program Evaluation Report DCAS PER-051, ‘Weldon Spring Plant’”

DCAS-PER-051 for Weldon Spring ORAUT-TKBS-0028-3, -4, -5, and -6

- TBD changes that increased dose and covered all operational periods and job types included:
  - Change in assumed isotopic ratios for uranium ore concentrates
  - Addition of a neutron-to-photon ratio
  - Addition of a geometry correction factor for external dose
  - Addition of a thoron exposure dose
  - Change in RU contaminate fractions
  - An increase in radon exposure estimate

SC&A's recommendations for Subtask 4 case reviews

- SC&A Subtask 4 case selection criteria included:
  1. Occupational medical x-rays with skin cancer(s)
  2. Environmental intakes consisting of exposure to uranium, thorium, and RU contaminants
  3. Environmental external ambient exposure
  4. Internal intakes consisting of exposure to uranium ore concentrates, thorium, RU contaminants, thoron, and radon
  5. External photon dose for an operator, material handler, or trade worker

Subtask 4: Conduct audits of a sample set of reevaluated DRs impacted by DCAS-PER-051

- November 16, 2023 – SPR tasked SC&A with a review of representative cases
- March 22, 2024 – NIOSH posted data for three cases for SC&A's review
- One or more of the DRs for the cases included recommended criteria, except for criterion 2 concerning environmental intakes consisting of exposure to uranium, thorium, and RU contaminants
- September 20, 2024 – SC&A provided a written report of the results of DR audit under subtask 4 to SPR

Case A dose reconstruction

- Energy employee (EE) worked as Operator at WSP
- EE was monitored for external and internal radiation exposure during employment
- Initial DR performed in 2004
- DR revised in 2014 per PER-051 and involved the following:
  - Change in assumed isotopic ratios for uranium ore concentrates
  - Addition of a neutron-to-photon ratio
  - Addition of a geometry correction factor for external dose
  - Change in RU contaminate fractions
- Both DRs resulted in probability of causation (POC) of <50 percent

Case A: 2004 assessment of external dose

- 2004 DR:
  - Assigned measured and missed photon dosimetry dose
  - Used overestimating 30 – 250 kilo-electron volt (keV) photon dose conversion factor (DCF) of 2.0 to all photon doses
  - Did not assign neutron dose

Case A: 2014 assessment of external photon dose

- 2014 DR:
  - Assigned measured and missed photon dosimetry dose
  - Assigned coexposure (CE) photon dose
  - Used appropriate 30 – 250 keV and >250 keV photon DCFs
- 2014 DR applied:
  - Film correction factor (FCF) of 1.1 to measured and CE 30–250 keV photon doses
  - Uncertainty factor (UF) of 1.4 to measured 30–250 keV and >250 keV photon doses
  - Construction trade worker adjustment factor of 1.4 to CE photon dose
  - Geometric correction factor of 2.1 to all photon doses because cancer location was in lower torso

Case A: 2014 assessment of neutron dose

- 2014 DR:
  - Assigned neutron dose using a neutron-to-photon ratio of 0.23 to measured, missed, and CE photon doses
  - Conservative neutron DCF of 1.0
  - International Commission on Radiological Protection Report-60 neutron dose correction factor of 2

Case A: 2014 versus 2004 assessment of external dose

- Total external dose assigned in 2014 DR was approximately half that assigned in 2004 DR
- 2014 DR used fewer overestimating methods than 2004 DR, but still applied very claimant favorable factors

Case A: Assessment of ambient dose

- External ambient dose was not assigned in either 2004 DR or 2014 DR because EE was monitored for external exposure, or CE dose was assigned
- SC&A concurs with NIOSH regarding there being no need to assign external ambient dose

Case A: Assessment of occupational medical x-ray exam dose

- 2004 DR assigned annual posterior-anterior (PA) exam dose
- 2014 DR assigned annual PA and lateral (LAT) exam dose
- 2014 DR x-ray dose assignment increased slightly from 2004 because 2014 DR assigned two (PA and LAT) views
- SC&A calculated occupational medical x-ray dose based on EE's records and concurs with NIOSH's dose assignments

Case A: Assessment of internal dose

2004 DR:

- Did not use bioassay records
- Assigned internal intakes and resulting doses assuming an intake of 28 radionuclides for a site with a reactor

2014 reworked DR:

- Used bioassay urinalysis results
- Used uranium (U)-234, uranium decay products and impurities (UDPI), and RU contaminant intakes to assign dose

SC&A's evaluation of Case A internal dose assignment

- Reviewed EE's files to obtain recorded bioassay data
- Calculated U-234, UDPI, and RU contaminant intakes for different solubility types
- Found type S uranium provided largest dose
- Verified that NIOSH used correct intake values and parameters in chronic annual dose (CAD) program to derive total internal dose
- Did not identify any findings but did have following observation

SC&A's observation 1: Use of ORAUT-OTIB-0002 versus use of bioassay data

- NIOSH stated in 2004 DR report:

  The intake applied in this DR is significantly larger than any intake based on the urinalysis results provided in the records. Therefore, the application of the hypothetical intake using maximizing assumptions is clearly claimant favorable.

- However:
  - SC&A could not locate any files accompanying the 2004 DR that showed that the dose reconstructor evaluated the dose using urinalysis results compared to using the recommendations in ORAUT-OTIB-0002
  - 2014 DR total internal dose assigned based on the EE's urinalysis results increased by 15 percent compared to 2004 DR which was based on ORAUT-OTIB-0002

SC&A's observation 1: Comments

- It should be noted that this is the second time SC&A has identified:
  - ORAUT-OTIB-0002, a hypothetical intake model, resulted in internal doses less than those derived from the EE's bioassay data.
  - ORAUT-OTIB-0002 was inappropriately used for a case that did not qualify for using ORAUT-OTIB-0002 guidance based on the EE's start date, and EE was monitored for uranium.
- Based on this second occurrence, SC&A questions how many other cases may have been impacted by the inappropriate use of ORAUT-OTIB-0002

Summary of SC&A's evaluation of reworked Case A

- SC&A found NIOSH's assumptions to be reasonable and doses correctly calculated
- SC&A did not have any findings but did have one observation concerning the 2014 reworked DR for Case A

Case B dose reconstruction

- EE worked in an administrative role at WSP
- EE was intermittently monitored for external exposure
- EE was monitored for internal intakes
- Initial DR performed in 2004
- DR revised in 2014 per PER-051 and involved the following:
  - Occupational medical x-rays (although it was not a skin cancer)
  - Change in uranium ore concentrates
  - Change in RU contaminants
- Both DRs resulted in POC of <50 percent

Case B: Assessment of external dose

- 2004 and 2014 DRs:
  - No positive doses recorded
  - Assigned missed external dose
  - Used 30–250 keV photon organ DCF and DCF of 1.0 for >15 keV electrons
  - Did not assign neutron dose
  - Assigned environmental dose for periods not monitored
- 2014 DR:
  - Applied a FCF of 1.1 to photon dose

Case B: 2014 versus 2004 assessment of external dose

- Total 2014 external dose decreased by one-half of the assigned dose in 2004 DR because:
  - 2014 DR used less overestimating methodology, limit of detect (LOD)/2 instead of LOD

Case B: SC&A's evaluation of external dose

- SC&A found no positive dosimeter readings
- SC&A calculated missed photon dose using appropriate correction factors
- SC&A was able to verify NIOSH's assigned missed dose

Case B: DR assessment of ambient dose

- 2004 DR:
  - Assigned onsite ambient dose as 30–250 keV photons and >15 keV electrons using Fernald Environmental Management Project due to similar operations
  - Assigned overestimate of onsite ambient doses for all years of employment
  - Did not prorating for partial years of employment or for years EE was monitored
- 2014 DR:
  - Assigned onsite ambient dose as 30–250 keV photons using TBD-4 annual dose rates
  - Assigned ambient dose for years EE was not monitored
  - Did not prorate for partial years of employment

SC&A's evaluation of ambient dose assignment

- Calculated onsite ambient dose using dose rates recommended in TBD-4
- Able to verify NIOSH's reworked onsite ambient dose
- 2014 DR assigned onsite ambient dose decreased significantly compared to 2004 DR because:
  - 2014 DR reflects use of current site-specific data rather than surrogate ambient external dose estimates
  - Use of less overestimating methods

Case B: Assessment of occupational medical x-ray exam dose

- 2004 DR assigned annual photofluorography x-ray exam dose
- 2014 DR assigned annual PA and LAT exam dose
- 2014 DR x-ray dose assignment decreased slightly from 2004 because 2014 DR used revised TBD-3
- SC&A calculated occupational medical x-ray exam dose based on EE's records and concurs with NIOSH's dose assignment

Case B: Assessment of internal dose

2004 DR:

- Did not use bioassay records
- Assigned internal intakes and resulting doses assuming an intake of 12 radionuclides for a site without a reactor

2014 reworked DR:

- Used bioassay urinalysis results
- Used U-234 and recycled RU contaminant intakes to assign dose
- Did not assign UDPI intakes because of work location

SC&A's evaluation of Case B internal dose assignment

- Reviewed EE's files to identify recorded bioassay data
- Calculated U-234 and RU contaminant intakes for different solubility types
- Found type S uranium provided largest dose
- Concur with NIOSH not assigning UDPI intakes because of work location
- Verified that NIOSH used correct intake values and parameters in CAD program to derive total internal dose
- SC&A noted, although EE's bioassay data did not result in a higher dose than hypothetical intake model, case did not qualify for using OTIB-0002

Summary of SC&A's evaluation of reworked Case B

- SC&A was found NIOSH's assumptions to be reasonable and doses correctly calculated
- SC&A did not have any findings or observations concerning 2014 reworked DR for Case B

Case C dose reconstruction

- EE worked in an administrative role at WSP
- EE was periodically monitored for external and internal radiation exposure during employment
- Initial DR performed in 2009
- DR revised in 2014 per PER-051 and involved the following:
  - Change in assumed isotopic ratios for uranium ore concentrates
  - Addition of a geometry correction factor for external dose
  - Change in RU contaminate fractions
- Both DRs resulted in POC of <50 percent

Case C: Assessment of external dose

- 2009 DR:
  - Assigned measured and missed external dose
  - Used 30–250 keV photon organ DCF and DCF of 1.0 for >15 keV electrons
  - Did not assign neutron dose
  - Did not assign environmental dose
- 2014 DR:
  - Assigned measured, missed, and CE external dose
  - Used 30–250 keV photon organ DCF and DCF of 1.0 for >15 keV electrons with an organ correction factor of 3.6
  - Applied a FCF of 1.1 to photon dose
  - Did not assign neutron dose
  - Did not assign environmental dose

Case C: 2014 versus 2009 assessment of external dose

- Total 2014 external dose increase substantially compared to 2009 DR because:
  - 2014 DR applied CE dose and missed dose during periods EE was not monitored
  - 2014 DR applied additional correction factors as required

Case C: SC&A's evaluation of external dose

- SC&A calculated measured, missed, and CE photon and electron doses using appropriate correction factors
- SC&A used overestimating method of applying both missed and CE doses during periods EE was not monitored (to verify NIOSH's dose assignments)
- SC&A was able to verify NIOSH's assigned doses except for the following finding and observations

SC&A's Finding 1

- **Finding 1:** NIOSH did not apply an uncertainty factor of 1.4 to measured photon dose
  - SC&A back calculated NIOSH's reworked measured photon dose
  - SC&A found NIOSH did not apply an UF of 1.4 to measured photon dose as recommended in TBD-6
  - Resulted in omission of 0.044 rem photon dose
  - SC&A found NIOSH did apply an UF of 1.4 to measured 30–250 keV and >250 keV photon doses in reworked DR for Case A

SC&A's observation 2

- **Observation 2:** Need consistence/clarification when applying film correction factor of 1.1 to missed photon dose
  - **Case A:** NIOSH did not apply a FCF of 1.1 to missed 30–250 keV photon dose but did apply it to measured and CE 30–250 keV photon doses
  - **Case B:** NIOSH did apply a FCF of 1.1 to missed (30–250 keV) photon dose (no positive dosimeter or CE dose assigned)
  - **Case C:** NIOSH did not apply a FCF of 1.1 to missed photon dose

Clarification need for application of film correction factor

- TBD-6 states:

  It is estimated that a correction equal to 10% of the less-than-250 keV values be added to the Hp(10) dose due to the contribution of these low-energy photons to penetrating dose that would have been absorbed by the thick filter.

- It is not clear if the FCF is to be applied to only measured 30–250 keV photon dose, or also to missed, CE, or assigned neutron doses
- It does not appear that the FCF of 1.1 was consistently applied in these three reworked cases

SC&A's observation 3

- **Observation 3:** Prorating of 1966 dose appears incorrect
  - It appears NIOSH prorated CE dose for partial year of employment correctly but did not prorate the potentially missed external dose, but instead assigned a complete year of 1966 missed dose
  - Resulted in NIOSH overestimating external dose

SC&A's observation 4

- **Observation 4:** Apparent inconsistent use of number of monitoring badge exchanges per year
  - SC&A duplicated NIOSH's missed doses in conjunction with CE doses in 2014 reworked case
  - However, the number of monitoring badge exchanges per year used by NIOSH to derive missed dose differed for photon compared to electron doses
- Typically, either a CE dose or a missed dose is assigned for unmonitored years. NIOSH's approach of assigning both CE dose and missed dose in this case is unusual, but claimant favorable

Case C: Assessment of ambient dose

- External ambient dose was not assigned in either 2009 DR or 2014 DR because EE was monitored for external exposure, or CE dose was assigned
- SC&A concurs with NIOSH regarding there being no need to assign external ambient dose

Case C: Assessment of occupational medical x-ray exam dose

- 2009 DR assigned annual PA and LAT exam dose
- 2014 DR assigned annual PA and LAT exam dose
- 2014 DR x-ray dose assignment decreased slightly from 2009 DR because 2014 DR used revised TBD-3
- SC&A calculated occupational medical x-ray exam dose based on EE's records and concurs with NIOSH's dose assignments

Case C: NIOSH's assessment of internal dose

- Used highest bioassay urinalysis results, excluding all others
- Used U-234 and recycled RU contaminant intakes to assign dose
- Did not assign UDPI intake because of work location
- Used appropriate revision of TBD-5

SC&A's evaluation of Case C internal dose assignment

- Reviewed EE's files to identify recorded bioassay data
- Calculated U-234 and RU contaminant intakes for different solubility types
- Found type S uranium provided largest dose
- Concur with not assigning UDPI intakes because of work location
- Verified that NIOSH used correct intake values and parameters in CAD program to derive total internal dose
- 2014 assigned internal dose decreased compared to 2009 DR because of revisions in TBD-5

Summary of SC&A's evaluation of reworked Case C

- Finding 1: NIOSH did not apply an uncertainty factor of 1.4 to measured photon dose
- Observation 2: Need consistence/clarification when applying film correction factor of 1.1 to missed photon dose
- Observation 3: Prorating of 1966 dose appears incorrect
- Observation 4: Apparent inconsistent use of number of monitoring badge exchanges per year

Summary of SC&A's subtask 4 evaluation of PER-051

- Case A Observation 1: Use of ORAUT-OTIB-0002 versus use of bioassay data
- Case C: one finding and 3 observations shown in previous slide

Questions?