Review of Three Advisory Board-Selected Cases
Reworked for the Evaluation of Westinghouse
Nuclear Fuels Division Template Revisions
(DCAS-PER-052, Subtask 4)

Kathleen Behling, SC&A, Inc.

Advisory Board on Radiation and Worker Health,
Subcommittee for Procedure Reviews

May 25, 2022
Summary of Westinghouse Nuclear Fuels Division operational history

- Westinghouse Nuclear Fuels Division (WNFD) received enriched uranium from the Atomic Energy Commission’s (AEC’s) Fernald plant and a shipment of plutonium from the West Valley facility that originated at Hanford.
- Records suggest that the plutonium also included thorium.
- AEC operations: 1971–1972
- Residual period: 1973–1979
DCAS-PER-052, “Westinghouse Nuclear Fuels Division”

- Issued March 2014 due to a June 2012 revision to the WNFD dose reconstruction (DR) template
- Revision resulted from identification of more than 9,600 new air samples
- Discovery of new air samples significantly increased inhalation intakes
- Template added three categories of unmonitored workers (operators/general laborers, supervisors, and other) based on their potential for exposure
SC&A’s review of DCAS-PER-052

- SC&A’s October 2014 review identified two findings
- Summary of findings:
  - Finding 1: Guidance for adjusting intakes based on “partially monitored” versus “completely unmonitored” status of a worker cannot be followed with available data provided in the revised template
  - Finding 2: The designation of Pu-241 as an alpha emitter is incorrect
- Findings discussed and closed at the April 28, 2015, SCPR meeting
ABRWH selected three reworked cases for SC&A’s review in April 2021, based on the following criteria:

1. one case that resulted in a POC between 45% and 50%
2. one case where internal dose was assigned based on the category of “operator”
3. one case where internal dose was assigned based on the category of “other”

SC&A reviewed reworked cases in December 2021 to determine if external and internal doses (case 1) and internal dose (cases 2 and 3) were correctly assessed in accordance with DCAS-PER-052
NIOSH’s reworked DRs

- NIOSH’s rework of the cases:
  - Used applicable DR tools
  - Recalculated all annual doses
  - Re-ran IREP

- Revised DR reports not sent to U.S. Department of Labor because the compensation decisions did not change
Case 1 background (POC 45–50%)

- Energy employee (EE) worked at WNFD for multiple periods of employment
- EE was periodically monitored for radiation exposure
- Diagnosed with qualifying cancer during the employment period
Comparison of NIOSH’s reworked doses versus original doses for case 1

<table>
<thead>
<tr>
<th>Dose categories</th>
<th>Reworked vs. original dose percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>External</td>
<td>86% decrease</td>
</tr>
<tr>
<td>Occupational medical</td>
<td>unchanged</td>
</tr>
<tr>
<td>Internal</td>
<td>284% increase</td>
</tr>
<tr>
<td>Total</td>
<td>172% increase</td>
</tr>
<tr>
<td>POC</td>
<td>90% increase</td>
</tr>
</tbody>
</table>
Original case 1 external photon dose calculations

- During periods when no external monitoring records found, ambient dose was assigned.
- All monitoring records showed zero readings and were treated as missed dose (limit of detection (LOD)/2), based on LOD = 0.040 rem and 19 zeros.
- Glovebox correction factor of 2.19 applied.
- Applied OCAS-IG-001, rev. 3, dose conversion factor (DCF) value.
- Doses entered in IREP as lognormal with geometric standard deviation (GSD) of 1.34.
- Assigned dose to the cancer site ~0.800 rem.
Original case 1 external ambient dose calculations

- Ambient dose assigned for each year of employment
- DCF value of 1.0 applied
- Doses entered in IREP as normal with 30% uncertainty
- Assigned dose to the cancer site ~1,000 rem
Original case 1 occupational medical dose calculations

- Medical dose calculated for each occupational x-ray
- Dose based on ORAUT-OTIB-0006, rev. 03 PC-1
- Doses <0.001 rem
- Not entered in IREP because <0.001 rem
Reworked case 1 external photon dose calculations

- Ambient dose assigned when EE not monitored
- Missed dose during residual period calculated based on February 2014 template values (significant decrease from 2012)
- Applied OCAS-IG-001, rev. 3, DCF value
- Doses entered in IREP as normal with 30% uncertainty
- Assigned dose to the cancer site ~0.300 rem
Reworked case 1 occupational medical dose calculations

- Medical dose calculated for each occupational x-ray
- Dose based on ORAUT-OTIB-0006, rev. 04
- Doses <0.001 rem
- Not entered in IREP because <0.001 rem
SC&A’s conclusions on case 1 external dose

- Reviewed the U.S. Department of Energy (DOE) files and 2012 and 2014 WNFD templates
- Confirmed reworked external doses were based on ambient and residual values from the 2014 WNFD template
- Residual dose decreased due to evaluation method changed from using residual period dosimetry to using standard derived residual doses given in the updated template, in accordance with ORAUT-OTIB-0070, rev. 01
- Correctly entered in the IREP table as chronic exposure with a normal distribution and 30% uncertainty
- Although doses calculated as stated, SC&A had two findings
Finding 1: Incorrect DCF was used to calculate dose

- 2014 template states exposure (R)-to-organ DCF for an isotropic exposure geometry to be applied
- Guidance does not specify if the DCF for the exposure or the ambient isotropic geometry is to be used
- Reworked case used claimant-favorable exposure DCF for anterior-posterior geometry (1.060)
Finding 2: NIOSH’s use of ambient dose during the operational period is not claimant favorable

- EE’s DOE records did not identify external dosimetry monitoring records for operational years
- Records show that the EE was monitored for internal exposure during that timeframe
- SC&A questions the assignment of ambient dose for this period, rather than a more claimant-favorable assignment, such as co-exposure dose
Original case 1 recorded internal dose calculations

- EE had positive uranium urine bioassays during operational period
- Highest value entered in the IMBA program, which projected an intake of U-234 of 132,730 dpm/day
- U-234 solubility types F, M, and S compared; type S provided for the largest dose
- Recycled uranium (RU) components of the U-234 intake were analyzed using 2% enriched uranium
- Annual doses entered in IREP as a chronic exposure with a lognormal distribution and an uncertainty of 3.0
- Assigned dose of ~4.500 rem
Original case 1 unmonitored internal dose calculations

- No bioassay monitoring results for 1 year
- Assigned internal dose based on facility air concentration data
- Unmonitored exposures were based on the geometric mean intake rate and assigned as Th-228 and Th-232
- Compared solubility types M and S; type M was considered the most claimant favorable
- Assumed the thorium intakes to be 50% Th-228 and 50% Th-232
- Doses entered in IREP with a lognormal distribution and an uncertainty of 4.638
- Modest dose assigned
Original case 1 missed internal dose calculations

- Urinalyses results during residual period less than minimum detectable activity (MDA)
- Chronic intake rate derived using half the MDA for plutonium
- Assumed a 12% 10-year-old fuel-grade plutonium mixture, based on Hanford
- Compared solubility types M, S, and Super S; type Super S was most claimant-favorable solubility type
- Annual doses entered in the IREP table as a chronic exposure with a triangular distribution (minimum equal to zero, the mode equal to the dose, and maximum equal to twice mode)
- Assigned dose of ~0.300 rem
Original case 1 unmonitored radionuclide dose calculations

- Template guidance:
  - Partially monitored workers with bioassays for uranium and/or plutonium should be assigned unmonitored exposure for those radionuclides (uranium, plutonium, or natural thorium) not monitored
  - Dose should be based on 95th percentile intake

- Unmonitored Th-228/232 exposures assessed using the 95th percentile intake rate for operational period

- Solubility types M, S, and Super S considered, with type M resulting in the most claimant-favorable dose

- Thorium intakes were assumed to be 50% Th-228 and 50% Th-232

- Entered in IREP as a chronic exposure as a constant

- Total dose assigned <0.100 rem
Reworked case 1 recorded internal dose calculations

- Rework identified three positive uranium urine bioassays during operational period
- Highest value entered in IMBA, which projected a U-234 intake of 132,730 dpm/day
- Adjustment for bioassay monitoring period resulted in inhaled intake of 53,273 dpm/day
- U-234 solubility types F, M, and S compared; type S provided for the largest dose
- RU components of the U-234 intake were analyzed using 2% enriched uranium, 12% 10-year-old fuel-grade plutonium, and natural thorium
- RU ratio for each radionuclide that resulted in the largest intake was applied
- Annual doses entered in IREP as a chronic exposure with a lognormal distribution and an uncertainty of 3.0
- Assigned dose of ~17.500 rem
Reworked case 1 unmonitored radionuclides dose calculations

- 2012 WNFD template separated unmonitored workers into three categories based on potential for exposure:
  - Operators/general laborers (95th percentile of air sample data)
  - Supervisors (50% of operator dose)
  - Other workers (10% of supervisor dose)

- EE considered a “supervisor”
- Calculated unmonitored dose based on plutonium mixture
- Solubility types M and S, with type M resulting in the most claimant-favorable dose
- Entered in IREP as a chronic exposure as a constant
- Total dose assigned ~1.000 rem
SC&A’s conclusions on reworked case 1
internal dose

- Reviewed DOE records, 2012 WNFD template, reworked CADW files, and IREP and confirmed that correct intake values were used to calculate recorded internal dose
- SC&A concurs with selection of “supervisor” for unmonitored dose based on DOE files and computer-assisted telephone interview
- SC&A verified unmonitored radionuclides:
  - Type M solubility resulted in the higher dose
  - Dose data appropriately entered in IREP table
  - Doses were assessed to the date of cancer diagnosis
- SC&A noted Pu-239 intake values for both 2% and 12% ratios entered in IREP (slight overestimate)
- SC&A had no findings about the assessment of internal dose
Case 2 background (operator)

- EE worked at WNFD for ~20 years of employment
- EE was not monitored for radiation exposure
- Diagnosed with qualifying cancers ~10 years after termination
Comparison of NIOSH’s reworked doses versus original doses for case 2

<table>
<thead>
<tr>
<th>Dose categories</th>
<th>Reworked vs. original dose percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>External</td>
<td>~60% decrease</td>
</tr>
<tr>
<td>Occupational medical</td>
<td>No change</td>
</tr>
<tr>
<td>Internal *</td>
<td>~16,600% increase</td>
</tr>
<tr>
<td>Total</td>
<td>~374% increase</td>
</tr>
<tr>
<td>POC</td>
<td>~158% increase</td>
</tr>
</tbody>
</table>

* SC&A evaluated only doses assigned for internal exposure, as specified by PER-052.
No monitoring, internal dose based on gross alpha air sampling data during operational period

Calculated unmonitored dose based on the geometric mean intake rate of 9.122 dpm/day inhalation and 0.182 dpm/day ingestion

Using CADW, compared plutonium, uranium, and thorium mixture intakes, with plutonium resulting in highest dose

12% 10-year-old plutonium mixture ratios applied

Solubility types M and S were evaluated, with type M resulting in the most claimant-favorable dose

Doses were entered in IREP as lognormal distribution and GSD of 4.638

Total dose of <0.050 rem assigned
Reworked case 2 internal dose calculations

- EE considered “operator” based on job title
- Used CADW to compare plutonium, uranium, and thorium mixture intakes, with plutonium resulting in highest dose
- 12% 10-year-old plutonium mixture ratios applied
- Operational intakes used for operational and residual periods
- Solubility types M and S were evaluated, with type M resulting in the most claimant-favorable dose
- Doses were entered in IREP as constant
- Assigned total dose of ~5.500 rem
SC&A’s conclusions on reworked case 2
internal dose

- Reviewed 2012 WNFD template, reworked CADW files, and IREP and confirmed that correct intake values were used to calculate internal dose
- SC&A concurs with selection of “operator” for unmonitored dose
- SC&A verified:
  - Plutonium type M solubility resulted in the highest dose
  - Dose data appropriately entered in IREP table
  - Doses were assessed to the date of cancer diagnosis
- SC&A had no findings about the assessment of internal dose for case 2
Case 3 background (other)

- EE worked at WNFD for multiple decades
- EE was not monitored for radiation exposure
- Diagnosed with qualifying cancer during employment
Comparison of NIOSH’s reworked doses versus original doses for case 3

<table>
<thead>
<tr>
<th>Dose categories</th>
<th>Reworked vs. original dose percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>External</td>
<td>~15% decrease</td>
</tr>
<tr>
<td>Occupational medical</td>
<td>~50% increase</td>
</tr>
<tr>
<td>Internal *</td>
<td>~700% increase</td>
</tr>
<tr>
<td>Total</td>
<td>~12% increase</td>
</tr>
<tr>
<td>POC</td>
<td>~10% decrease</td>
</tr>
</tbody>
</table>

* SC&A evaluated only doses assigned for internal exposure, as specified by PER-052.
Original case 3 internal dose calculations

- No monitoring, internal dose based on gross alpha air sampling data during operational period
- Calculated unmonitored dose based on the geometric mean intake rate of 9.122 dpm/day inhalation and 0.182 dpm/day ingestion
- Using CADW, compared plutonium, uranium, and thorium mixture intakes, with plutonium resulting in highest dose
- 12% 10-year-old plutonium mixture ratios applied
- Solubility types M and S were evaluated, with type M resulting in the most claimant-favorable dose
- Doses were entered in IREP as lognormal distribution and GSD of 4.638
- Total dose of <0.050 rem assigned
Reworked case 3 internal dose calculations

- EE considered “other” worker based on job title
- Used CADW to compared plutonium, uranium, and thorium mixture intakes, with plutonium resulting in highest dose
- 12% 10-year-old plutonium mixture ratios applied
- Operational intakes used for operational and residual periods
- Solubility types M and S were evaluated, with type M resulting in the most claimant-favorable dose
- Doses were entered in IREP as constant
- Assigned total dose of ~0.200 rem
SC&A’s conclusions on reworked case 3

**Internal dose**

- Reviewed 2012 WNFD template, reworked CADW files, and IREP and confirmed that correct intake values were used to calculate internal dose
- SC&A concurs with selection of “operator” for unmonitored dose
- SC&A verified:
  - Plutonium type M solubility resulted in the highest dose
  - Dose data appropriately entered in IREP table
  - Doses were assessed to the date of cancer diagnosis
- SC&A had no findings about the assessment of internal dose for case 3 (criterion 3)
Summary conclusions for three cases reviewed under DCAS-PER-052

SC&A reviewed three cases based on these criteria:
1. one case that resulted in a POC between 45% and 50%
2. one case where internal dose was assigned as “operator” category
3. one case where internal dose was assigned as “other” category

SC&A had two findings about the rework of case 1:
- Finding 1: Incorrect DCF was used to calculate dose
- Finding 2: NIOSH’s use of ambient dose during the operational period is not claimant favorable

Internal doses for cases 2 and 3 were reevaluated in accordance with DCAS-PER-052
Observation 1: Inadequate reviews of DR methodology templates

- During this review, SC&A became aware that, not only was the WNFD template modified in 2012, as addressed in PER-052, but the template was also revised in 2014 and 2016.
- Since DR templates are not formally published, the Board is not aware of their existence or changes introduced in these templates unless a PER is issued (only when doses increase) or SC&A reviews a case from a site where the template is used for DR.
- SC&A recommends that the Board:
  - Be provided with a complete list of sites where DRs are being performed using a template.
  - Be informed when these templates are revised.