



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

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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

DCAS-PER-052 subtask 4 review of three reworked cases

- ◆ 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

Dose categories	Reworked vs. original dose percentage
External	86% decrease
Occupational medical	unchanged
Internal	284% increase
Total	172% increase
POC	90% increase

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

SC&A's finding 1 on case 1 external dose

- ◆ 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)

SC&A's finding 2 on case 1 external dose

- ◆ 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

Dose categories	Reworked vs. original dose percentage
External	~60% decrease
Occupational medical	No change
Internal *	~16,600% increase
Total	~374% increase
POC	~158% increase

* SC&A evaluated only doses assigned for internal exposure, as specified by PER-052.

Original case 2 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 <math><0.050</math> 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

Dose categories	Reworked vs. original dose percentage
External	~15% decrease
Occupational medical	~50% increase
Internal *	~700% increase
Total	~12% increase
POC	~10% decrease

* 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 <math><0.050</math> 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



Questions?