REPORT TO THE ADVISORY BOARD ON RADIATION AND WORKER HEALTH

National Institute of Occupational Safety and Health

Audit of Case PIID* from Fernald

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U. Hans Behling, PhD, MPH</td><td rowspan="2">Supersedes:

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1.0 SUMMARY BACKGROUND INFORMATION

This report presents the results of an independent audit of a dose reconstruction performed by the National Institute of Occupational Safety and Health (NIOSH) for an energy employee that worked at the Feed Materials Production Company (FMPC or Fernald) for nearly **PIID*** years, from **PIID***, to **PIID***, as a **PIID***.

As a result of the claimant's employment, the worker experienced occupational exposures to external radiation sources, as well as exposure to internally deposited radioactive material. The worker was periodically monitored for uranium intake by analyzing urine samples for total uranium. External exposures were **not** evaluated by NIOSH for this case, so factors involved in the employee's external dose estimates were not evaluated.

The employee was diagnosed with lung cancer on **PIID***. The employee was also diagnosed with numerous skin cancers between **PIID*** and **PIID***. Because lung cancer was involved, NIOSH first determined the probability of causation (POC) for the lung cancer due to inhalation of alpha-emitting radionuclides. Annual dose to the lung from the time of initial employment to the time of diagnosis was determined from urine bioassay results measured during the years of employment, and the results were input into IREP. Per NIOSH and ORAU procedures, this case was determined to have a POC of 57.4% for lung cancer.

Table 1 presents an overall summary of NIOSH's dose reconstruction.

Table 1. Summary of External Exposures as Estimated by NIOSH

	Appendix A Exposure Entry No.	Dose (rem)
External Dose:		
▪ Photon Dosimeter Dose	NC*	—
▪ Photon Missed Dose	NC*	—
▪ Neutron Dosimeter Dose	NC*	—
▪ Neutron Missed Dose	NC*	—
▪ Occupational Medical	NC*	—
▪ Onsite Ambient	NC*	—
Internal Dose:	1 – 50	66.388
Total		66.388

*NC = Not considered because exposure scenario was not needed to show causation

1.1 AUDIT OBJECTIVES

SC&A's audit was performed with the following objectives:

- To determine if NIOSH assigned doses that are consistent with monitoring records provided by the DOE and with the information contained in the CATI report
- To determine if the dose reconstruction process complied with applicable procedures that include generic procedures developed by NIOSH and ORAUT, as well as data/procedures that are site-specific
- In instances when procedure(s) provide more than one option or require subjective decisions, determine if the process is scientifically defensible and/or claimant favorable

In pursuit of these objectives, a two-step process is followed in this audit. The first step of this audit is to independently duplicate, and therefore validate, doses derived by NIOSH. This step of the audit process is not only contractually mandated under Task 4, but provides NIOSH and the Advisory Board with a high level of assurance that the SC&A reviewer understands which procedures, models, site-specific data, and assumptions NIOSH used to perform its dose reconstruction. The second step of the audit critically evaluates whether the methods employed by NIOSH are technically defensible, consistent with applicable procedures, and claimant favorable.

Lastly, in compliance with the Privacy Act, this report makes no reference to the claimant's name, SSN, address, or any personal data that might reveal the identity of the claimant.

1.2 SUMMARY OF AUDIT FINDINGS

An overview of SC&A's audit findings for Case PIID* is provided in Table 2 in the form of a checklist. This checklist evaluates the data collection process, information obtained from the CATI interview, and all methods used in the dose reconstruction. When deficiencies are identified by the audit, such deficiencies are further characterized with regard to their impact(s) by means of the following definitions: (1) **low** means that the deficiency has only a marginal impact on dose; (2) **medium** means that the deficiency substantially impacts the dose, but is unlikely to impact the compensability of the case; and (3) **high** means that the deficiency substantially impacts the dose and may also impact the compensability of the case. A full description of deficiencies identified in the checklist is provided in the text of the audit that follows.

Table 2. Case Review Checklist

CASE PIID*	ASSIGNED DOSE: 66.388 rem	POC: 57.4%

No.	Description of Technical Elements of Review	Audit Response			If No, Potential Significance		
		YES	N/A	NO	LOW[1]	MEDIUM[2]	HIGH[3]
A. REVIEW OF DATA COLLECTION:							
A.1	Did NIOSH receive all requested data for the DOE or AWE site from any relevant data source?	✓					
A.2	Is the data used by NIOSH for the case adequate to make a determination with regard to POC?	✓					
B. REVIEW OF INTERVIEW AND DOCUMENTATION PROVIDED BY CLAIMANT							
B.1	Did NIOSH properly address all work history dates/locations of employment reported by claimant?		✓				
B.2	Did NIOSH properly address all incidents/occurrences reported by claimant?		✓				
B.3	Did NIOSH properly address monitoring/ personal protection/work practices reported by claimant?		✓				
B.4	Is the interview information consistent with data used for dose estimate?		✓				
C. REVIEW OF PHOTON DOSES							
C.1	Was the appropriate procedure used for determining:						
C.1.1	- Recorded Photon Dose?		✓				
C.1.2	- Missed Photon Dose?		✓				
C.1.3	- Occupational Medical Dose?		✓				
C.1.4	- Onsite-Ambient Dose?		✓				
C.2	Did the DR properly account for all:						
C.2.1	- Recorded Photon Dose?		✓				
C.2.2	- Missed Photon Dose?		✓				
C.2.3	- Occupational Medical Dose?		✓				
C.2.4	- Onsite-Ambient Dose?		✓				
C.3	Is the recorded/assigned dose properly converted to the organ dose of interest for:						
C.3.1	- Recorded Photon Dose?		✓				
C.3.2	- Missed Photon Dose?		✓				
C.3.3	- Occupational Medical Dose?		✓				
C.3.4	- Onsite-Ambient Dose?		✓				
C.4	Is the organ dose uncertainty properly determined for:						
C.4.1	- Recorded Photon Dose?		✓				
C.4.2	- Missed Photon Dose?		✓				
C.4.3	- Occupational Medical Dose?		✓				
C.4.4	- Onsite-Ambient Dose?		✓				
D. REVIEW OF SHALLOW (i.e., 7 mg/cm^2)/ELECTRON DOSES							
D.1	Was the appropriate procedure used for determining:						
D.1.1	- Recorded Shallow/Electron Dose?		✓				
D.1.2	- Missed Shallow/Electron Dose?		✓				
D.1.3	- Onsite Ambient Dose?		✓				
D.2	Did the DR properly account for all:						
D.2.1	- Recorded Shallow/Electron Dose?		✓				
D.2.2	- Missed Shallow/Electron Dose?		✓				
D.2.3	- Onsite Ambient Dose?		✓				

[1] **Low** means that the deficiency has only a marginal impact on dose.
[2] **Medium** means that the deficiency substantially impacts the dose, but is unlikely to impact the compensability of the case.
[3] **High** means that the deficiency substantially impacts the dose and may also impact the compensability of the case.

CASE PIID*	ASSIGNED DOSE: 66.388 rem	POC: 57.4%

No.	Description of Technical Elements of Review	Audit Response			If No, Potential Significance		
		YES	N/A	NO	LOW[1]	MEDIUM[2]	HIGH[3]
D.3	Is the recorded/assigned dose properly converted to the organ dose of interest for:						
D.3.1	- Recorded Shallow/Electron Dose?		✓				
D.3.2	- Missed Shallow/Electron Dose?		✓				
D.3.3	- Onsite Ambient Dose?		✓				
D.4	Is the organ dose uncertainty properly determined for:						
D.4.1	- Recorded Shallow/Electron Dose?		✓				
D.4.2	- Missed Shallow/Electron Dose?		✓				
D.4.3	- Onsite Ambient Dose?		✓				
E. REVIEW OF NEUTRON DOSES							
E.1	Was the appropriate procedure used for determining:						
E.1.1	- Recorded Neutron Dose?		✓				
E.1.2	- Assigned Neutron Dose?		✓				
E.1.3	- Missed Neutron Dose?		✓				
E.2	Did the DR properly account for all:						
E.2.1	- Recorded Neutron Dose?		✓				
E.2.2	- Assigned Neutron Dose?		✓				
E.2.3	- Missed Neutron Dose?		✓				
E.3	Is the recorded/assigned dose properly converted to the organ dose of interest for:						
E.3.1	- Recorded Neutron Dose?		✓				
E.3.2	- Assigned Neutron Dose?		✓				
E.3.3	- Missed Neutron Dose?		✓				
E.4	Is the organ dose uncertainty properly determined for:						
E.4.1	- Recorded Neutron Dose?		✓				
E.4.2	- Assigned Neutron Dose?		✓				
E.4.3	- Missed Neutron Dose?		✓				
F. REVIEW OF INTERNAL DOSE: BASED ON HYPOTHETICAL MODEL							
F.1	Is the use of the selected hypothetical internal dose model appropriate, based on the likely POC value?		✓				
F.2	Is the use of a hypothetical internal dose model appropriate/conservative, based on claimant's available bioassay data,?		✓				
F.3	Was the hypothetical dose value correctly derived?		✓				
G. REVIEW OF INTERNAL DOSE: BASED ON BIOASSAY/IMBA							
G.1	Was the appropriate procedure (or section of procedure) used for determining likely (>50%), unlikely (<50%), or undetermined POC and compensability?	✓					
G.2	Are bioassay data sufficiently adequate for internal dose reconstruction?	✓					
G.3	Are assumptions pertaining to dates of uptake reasonable/conservative?	✓					
G.4	Are critical parameters (e.g., solubility class, particle size, etc.) used for IMBA organ dose estimates appropriate?	✓					
G.5	Are assigned uncertainties (measurement errors) for bioassay data (used as input to IMBA) appropriate?	✓					
H. Total Number of Deficiencies and Their Combined Potential Significance				0			

[1] **Low** means that the deficiency has only a marginal impact on dose.
[2] **Medium** means that the deficiency substantially impacts the dose, but is unlikely to impact the compensability of the case.
[3] **High** means that the deficiency substantially impacts the dose and may also impact the compensability of the case.

2.0 AUDIT OF INTERNAL DOSES

On the basis of a preliminary review of information/data, it was concluded that only a partial dose reconstruction was needed in behalf of this claim.

The employee was diagnosed with lung cancer on **PIID*** . The employee was also diagnosed with numerous skin cancers between **PIID*** and **PIID*** . Because lung cancer was involved, NIOSH first determined the probability of causation (POC) for the lung cancer due to inhalation of alpha-emitting radionuclides alone. Because the POC was greater than 50% for lung cancer, additional evaluations were not necessary. Thus, internally deposited radionuclides resulting in dose to the lungs were the primary exposure evaluated in the dose reconstruction. Uranium bioassay results were the basis for the reconstruction.

The employee's dose records, provided by DOE, show that the claimant's urine was analyzed via bioassay for total uranium on 73 occasions. Because the urinalysis was for total uranium concentration in the urine (µg/L), the type of uranium to which the employee was exposed is not known. The uranium used and found at Fernald ranged from depleted uranium to enriched uranium, so NIOSH assumed a radionuclide mix consistent with natural uranium. This means that for the natural uranium found at the site, the material had an activity concentration of 0.338 pCi/µg of uranium-234 and 0.334 pCi/µg of uranium-238.

The total uranium concentration results (µg of uranium per L of urine) from the bioassays were in units of µg/L. Total urine excretion volume per day was assumed to be 1.4 L/day.

According to SD-2008, non-occupational natural uranium is excreted in urine at a rate of 0.05 to 0.5 µg/day. In order to minimize dose, NIOSH selected the upper bound of this range, 0.5 µg/day, and subtracted that value from the daily excreted uranium calculated from the bioassay results.

The above factors were used with the bioassay results to determine the daily radioactivity excreted in the urine in units of pCi/day of U-234, U-235, and U-238).

Other assumptions necessary to determine the lung dose pertained to the solubility of uranium. The employee's work history showed that the claimant in Plants 1, 2, 3, 4, and 5 may have uranium in the three solubility classes (Type F, Type M, and Type S). Technical references report solubility components in some airborne contamination samples at Fernald to be greater than 60% insoluble. NIOSH assumed a mix of 30% Type S and 70% Type M in performing this dose reconstruction, and intake was assumed to be chronic.

From urine data, IMBA was used to first calculate the inhalation intake to the lung. The previously calculated radioactivity content in urine and the solubility factors above were used as input. Secondly, based on inhalation intake, IMBA was used to calculate annual lung dose. The ICRP 66 lung model with default aerosol characteristics was assumed.

The IMBA results included annual dose to the lungs from U-234, U-238, and total uranium. Annual results were calculated from the time of initial employment to the year of cancer

diagnosis, **PIID***. The calculation resulted in a total dose to the lungs of 66.388 rem. For reasons of efficiency, uncertainty was not included.

Appendix A presents the results of NIOSH's reconstruction of the annual lung doses to the energy employee for the purpose of deriving the POC using IREP. In addition to the lung dose, the claimant's status as a former smoker was also taken into account in the IREP POC calculation.

Because the POC for the lung cancer from bioassay data along was 57.4%, additional dose determinations, such as external dose, occupational medical dose, etc., were not performed.

2.1 REVIEWER'S COMMENTS

This partial dose reconstruction was performed on the assumption that the POC was likely >50%. As such, the procedure to follow for the dose estimate is given in OCAS-IG-002 (NIOSH 2002), Section 6.2. It appears that steps 1–5 of that procedure were followed, but step 6 was not. Step 6 directs the assessor to repeat the preliminary dose estimate for all potential solubility classes to determine the one that produces the **lowest** dose. The assessor selected 30% Type S and 70% Type M, with no documentation as to whether that would produce the lowest dose result. In fact, the ratio of solubility classes selected was stated to be claimant favorable. While this ratio of solubility classes appears to be reasonable, based on site history, it does not comply with the implementation guide.

The ratio of uranium radionuclides used in the dose estimation was assumed to be natural uranium, without consideration of enriched uranium. This would result in a likely underestimate of the claimant's dose, and is valid for this case, where the claimant was compensated.

The total daily urine excretion volume of 1.4 L/day assumed by the assessor is reasonable. The subtraction of 0.5 µg/day total uranium from naturally-occurring (non-occupational) sources is also valid in this "efficiency" model that provides the lowest dose. Selecting the upper end of the range for elimination of natural uranium would support that model.

The calculations performed by NIOSH to estimate the uranium radioactivity excreted per day (and subsequently used as input to IMBA) were performed correctly. The IMBA calculations were correctly reported in the dose reconstruction and used as input to IREP. The use of the ICRP 66 lung model and default aerosol characteristics are also valid assumptions.

In summary, this audit concludes that the calculations performed in the reconstruction of dose are generally valid and procedurally compliant. While most of the steps performed in this dose reconstruction comply with NIOSH procedures, the selection of solubility class should have been one that result in the lowest dose. A reference to "claimant favorable" should not have been a deciding factor for determining this parameter, since the objective of a partial dose reconstruction (with a likely POC >50%) is to **minimize** the dose.

REFERENCES

NIOSH 2002, “Internal Dose Reconstruction Implementation Guideline,” OCAS-IG-002, Rev 0, August 2002.

APPENDIX A: IREP INPUT

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