ISSUES RESOLUTION MATRIX FOR FERNALD SITE PROFILE AND SEC PETITON

Doc	No	Finding Text	History	SC&A Comments	NIOSH Response to Revision 0	Status
TBD	7	The TBD does not specify a method for estimating doses in the raffinate streams, which are uranium-poor, from ore processing in Plant 2/3. These doses may be very difficult to calculate, especially for high-grade ores, notably pitchblende ore from Congo.	**This also pertains to SEC Finding 4.2-2 and Primary SEC Issue 4:** "Review of radon breath data for adequacy for reconstructing doses due to the inhalation of Ra-226 and Th-230." October 14, 2008 – NIOSH responded: *NIOSH has radon breath analyses for raffinate transfer operations and air sample data in the Plant 2/3 raffinate handling area sufficient to bound possible intakes and allow claimant-favorable dose reconstructions of sufficient accuracy.* The NIOSH approach is contained in ORAUT-RPRT-0052 (ORAUT 2011b). RPRT-0052, pp. 24–25: Transfer of drummed K65 raffinate to Silos 1 and 2 late 1952–June 1953; radon breath data available. Q-11 transfer 1954–1957; subsumed in SEC. The concern for the raffinate streams can be bounded by the extensive "radon breath analyses-to-radium deposition" performed during the K-65 raffinate drum disposal operation. In addition, confirmatory air monitoring data in Plant 2/3 specific to the raffinate operations provides assurance that exposures are adequately bounded. The raffinates were wet (minimizing air contamination production) and enclosed in process piping. Other uranium daughters in addition to Ra-226 intake can be adequately bounded by ratioing to Ra-226, using the isotopic analyses of the silo contents. A detailed discussion of SEC Issue 4 took place at the April 19, 2011, WG meeting (ABRWH 2011), where SC&A agreed that	10/15/2013: SEC recommends this issue be changed to "in abeyance" pending revised TBD. 4/10/2014: New revision of ORAUT-TKBS-0017-5 not yet available. October 2013 recommendation holds. 8/25/2014: October 2013 recommendation holds. 11/18/2014: SC&A believes this issue is far too complex to be put in abeyance without a formal review. SC&A recommends that it be changed to "open" until we have an opportunity to review the revised internal dose portion of the Fernald site profile. 12/4/2014: This issue was discussed during work group deliberations and it was recommended this finding be put "in progress" while NIOSH develops methods for assessing dose to raffinates. (ABRWH 2014c, p. 149) **7/28/2017: This issue was discussed during Work Group deliberations. NIOSH's position is that there is no exposure potential to uranium and radium-poor raffinates due to the nature of process equipment and physical form of the material. NIOSH is to provide an official written position on uranium and radium-poor raffinates exposure potential. SC&A recommends that the issue remain In Progress pending release of formal NIOSH position.**	ORAUT-RPRT-0052, "Feed Materials Production Center Internal Dose Topics," provides a method for estimating raffinate streams, which will be incorporated into ORAUT-TKBS-0017-5, "Technical Basis Document for the Fernald Environmental Management Project (FEMP) – Occupational Internal Dose," and ORAUT-TKBS-0017-4, "Fernald Environmental Management Project – Occupational Environmental Dose," revisions. ORAUT-OTIB-25, "Estimation of Radium-226 Activity in the Body from Breath Radon-222 Measurements," which is included in ORAUT-RPRT-0052, provides a method for reconstructing doses from radon breath analyses results from 1952–1954 and this methodology will be included into the internal TBD revision. 10/24/2017: NIOSH's position is that there was little potential for exposure to uranium- and radium-poor raffinates, since they were liquids that were pumped to disposal pits. If there were	**In Progress**

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			NIOSH's methods were bounding and sufficiently accurate.		exposures to uranium- and radium-poor raffinates, doses from those exposures cannot be reconstructed with sufficient accuracy, given the information available to NIOSH. Any such exposures occurred within the period of the existing "thorium" SEC class. Therefore no further SEC action is required, and doses resulting from exposure to uranium- and radium-poor raffinates will not be included in partial dose reconstructions.	
TBD	8	Workers who may have worked with raffinates may be missed by the protocol specified in Vol. 5 of the TBD. The guidelines for determining which workers were exposed to raffinate dusts are too restrictive and place far too great a reliance on completeness of records for job assignments, or in the alternative, place the burden of proof on the claimant. They have not been adequately justified by measurements and are not claimant favorable.	See response to **Finding 7**.	10/15/2013: See response to Finding 7. 11/18/2014: SC&A believes this issue is far too complex to be put in abeyance without a formal review. SC&A recommends that it be changed to "open" until we have an opportunity to review the revised Internal Dose portion of the Fernald site profile. 12/4/2014: This issue was discussed during Work Group deliberations and it was recommended this finding be put "in progress" while NIOSH develops methods for assessing dose to raffinates. (ABRWH 2014c, p. 149) **7/28/2017: This issue remains In Progress (see status details under Finding 7).**	See NIOSH response 7.	**In Progress**

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TBD	9	The data on trace contaminants in RU in the Fernald TBD are incomplete and appear to be incorrect. Different official documents have very different values for various aspects of RU data, including production and contamination. The contradictions have not been sorted out in the TBD.	This finding is the same as SEC Finding No. 4.1-6. NIOSH responded as follows: *Some production data are admittedly conflicting. Since dose reconstruction does not depend directly on production data, sufficient data are available to enable a bounding estimate based on the ratio of RU contaminates to the uranium intake determined from the uranium urinalyses. Recommended defaults have been chosen that adequately bound all of the operational data. The shipment(s) from Paducah Gaseous Diffusion Plant were of short duration, the increased hazards were recognized and adequately controlled, and recognized as doubling the total inventory of RU contaminants at FMPC, which in turn was factored into the default assumptions.* After many white paper exchanges and deliberations, NIOSH demonstrated that they could place a plausible upper bound on intakes from three principal RU constituents.	10/15/2013: SC&A recommends finding be changed to "in abeyance" pending revised TBD. 4/10/2014: New revision of ORAUT-TKBS-0017-5 not yet available. October 2013 recommendation holds. ORAUT-RPRT-0052 (July 2011), Section 4.5, Table 18 does not reflect agreed-upon constituent levels from WG discussions on February 9, 2012 [See SC&A white paper titled *SC&A's Response to NIOSH's Subgroup 10A Impact Analysis Dated November 1, 2011* (SC&A 2012a)]. Need to verify that what was agreed upon in WG meetings is, in fact, incorporated into ORAUT-TKBS-0017-5 and any related guidance documents. 8/25/2014: SC&A recommends that this finding be kept in abeyance pending revision of ORAUT-TKBS-0017-5. 11/18/2014: August 2014 recommendation holds. 12/4/2014: August 2014 recommendation holds. (ABRWH 2014c, p. 153) **7/28/2017: This issue was discussed during the Fernald WG meeting. NIOSH has revised its position on recycled uranium contaminant ratios for the period 1961–1972. NIOSH is to provide an official written position on the revised ratios. Issue to change from "In Abeyance" to "In Progress."**	ORAUT-RPRT-0052, "Feed Materials Production Center Internal Dose Topics" provides an upper bound on intakes from RU constituents, which will be incorporated into ORAUT-TKBS-0017-5, "Technical Basis Document for the Fernald Environmental Management Project (FEMP) – Occupational Internal Dose," and ORAUT-TKBS-0017-4, "Fernald Environmental Management Project – Occupational Environmental Dose," revisions. **10/24/2017:** NIOSH's use of the 10 ppb Pu in RU through 1972 is based on the lot data found in Attachment C of the Ohio Field Office Report (SRDB 003644). From a quick review of the lots identified as being processed prior to 1973, it appears that more than 95% of the identified Pu concentrations are below 1 ppb. Of those that are above 1 ppb Pu, most of those are still below 10 ppb Pu. This means that any potential to exposures to RU with Pu concentrations great than 10 ppb would be considered rare and to be short in duration. The remaining and thus majority of any worker's exposure time	**In Progress**

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					would have been associated with materials well below the recommended default level of 10 ppb Pu. Therefore, NIOSH cannot identify any reason to believe that any worker could have an exposure for which the recommended default level of 10 ppb Pu would not be adequately conservative and bounding.	
TBD	11	The suggested approach for RU dose estimation in the TBD is claimant favorable for many RU workers, but not claimant favorable for others and for some periods; it is not based on an evaluation of the available data.	This is similar to SEC Primary Issue 3. After many white paper exchanges and deliberations, NIOSH demonstrated that they could place a plausible upper bound on intakes from the three principal RU constituents. Subsumed into SEC pre-1979. Coworker model applicable 1979–1986 when WMCO took over M&O from NLO and for non-SEC claimants.	10/15/2013: SC&A recommends finding be changed to "in abeyance" until agreed upon method is incorporated into the TBD. 8/25/2014: SC&A recommends keeping this finding in abeyance pending upcoming revision to ORAUT-TKBS-0017-5. 11/26/2014: SC&A recommendation from 8/25/2014 holds. 12/4/2014: This item was not discussed at the Work Group meeting. Recommendation from 8/25/2014 holds. **7/28/2017: Issue to change from "In Abeyance" to "In Progress" (see status details under Finding 9).**	ORAUT-RPRT-0052, "Feed Materials Production Center Internal Dose Topics" provides an upper bound on intakes from RU constituents for all workers, which will be incorporated into ORAUT-TKBS-0017-5, "Technical Basis Document for the Fernald Environmental Management Project (FEMP) – Occupational Internal Dose," and ORAUT-TKBS-0017-4, "Fernald Environmental Management Project – Occupational Environmental Dose," revisions. **10/24/2017:** See NIOSH response details under Finding 9.	**In Progress**
SEC P	3	Default concentrations (on U mass basis) of Pu-239, Np-237, and other isotopes associated with RU at	After many white paper exchanges and deliberations, NIOSH demonstrated that they could place a plausible upper bound on intakes from the three principal RU constituents.	10/15/2013: SC&A recommends issue be placed "in abeyance" until implemented in site profile. 4/10/2014: Recommend that related site profile issues be placed in abeyance. SC&A will need	ORAUT-RPRT-0052, "Feed Materials Production Center Internal Dose Topics," provides an upper bound on intakes from RU constituents for all workers, which will be	**In Progress**

Doc	No	Finding Text	History	SC&A Comments	NIOSH Response to Revision 0	Status
		Fernald may not be bounding for some classes of worker activities, buildings, and time periods.		to review relevant TBD revisions to determine whether our concerns are adequately addressed. See response to Finding 9. 8/25/2014: SC&A recommends that this finding be kept in abeyance pending revision of ORAUT-TKBS-0017-5. 11/26/2014: August 2014 recommendation holds. However, note that only the three primary contaminants have been addressed and other radionuclides may be relevant to dose reconstruction (for example, Am-241 from Finding 10). 12/4/2014: Based on discussions occurring during the Work Group meeting, it was recommended this finding be changed from "in abeyance" to "in progress" pending NIOSH investigations into potential exposures to Am-241 in recycled uranium. See also update to Finding 10. (ABRWH 2014c, pp 154–167). **7/28/2017: This item was discussed during the WG meeting. The issue of RU contaminant ratios is no longer an SEC issue. However, NIOSH has altered its approach to assignment of RU contaminants and is to provide an official written response on the issue. The WG recommends the issue remain "In Progress" pending development and discussion of NIOSH's new position (see TBD Findings 9 and 11). The portion of this finding related to Am-241 has been recommended for closure (see TBD Finding 10).**	incorporated into ORAUT-TKBS-0017-5, "Technical Basis Document for the Fernald Environmental Management Project (FEMP) – Occupational Internal Dose," and ORAUT-TKBS-0017-4, "Fernald Environmental Management Project – Occupational Environmental Dose," revisions. **10/24/2017:** See NIOSH response details under Finding 9.	
Thorium White	Th-4	Unless sufficient evidence exists that thorium exposure potential at Fernald was restricted to solubility class "W," NIOSH should	This issue was first discussed during the December 2014 Work Group meeting; however, no path forward was agreed upon at that time.	**7/28/2017: This issue was discussed at the WG meeting. NIOSH is to reconsider the assumed solubility class for application of 10% DAC values used in unmonitored thorium dose reconstruction (1990–1994). NIOSH to provide official written position on issue. WG recommends finding be**	It is standard industry practice to utilize the more restrictive DAC value for the purposes of controlling airborne contamination. Therefore, the lower class W DAC is appropriate.	**In Progress**

Doc	No	Finding Text	History	SC&A Comments	NIOSH Response to Revision 0	Status
		consider using the more conservative and claimant favorable DAC value for solubility class "Y."		**designated as In Progress.**	**10/24/2017:** SRDB Ref. ID# 4152, "Radiological Air Sampling Program and Air Sampling Philosophy," (February 1989) indicates that Fernald applied the class W thorium DAC for controlling airborne activity areas. This document identifies areas where thorium was present and states for each that the class W DAC shall be used or is in effect. Therefore, the usage of 10% DAC for Class W Th-232 in Table 5-40 is appropriate for the assignment of unmonitored thorium intakes in 1990-1994. Reference to SRDB Ref. ID 4152 and supporting text has been incorporated into Section 5.5.2.3.2 of the current working draft of ORAUT-TKBS-0017-5, Rev. 04.	
Thorium White Paper	Th-6	The underlying assumptions employed to reconstruct doses to thoron appear to be arbitrary and are not well established or referenced. The assumptions concerning thorium source term inventory, release	This issue was first discussed during the December 2014 Work Group meeting; however, no path forward was agreed upon at that time. Appendix B to the Fernald internal dose TBD contains a discussion of SC&A's concerns.	**7/28/2017: This issue was discussed at the WG meeting. NIOSH is to consider modeling Building 65 thoron doses specifically. In addition, NIOSH is to provide an official position on assumed occupancy factors for thoron exposure. The WG recommends that this finding be designated as In Progress.**	— **10/24/2017:** NIOSH response presented below.	**In Progress**

Doc	No	Finding Text	History	SC&A Comments	NIOSH Response to Revision 0	Status
		fraction, equilibrium factor, occupancy time, and specific activity of thoron should be more carefully defined based on credible documentation and site-specific records.				

10/24/2017:

1. The following information provides a better explanation of how default values for thoron exposure in storage facilities are estimated:

   The highest FMPC thoron exposures are likely to be associated with storage facilities because the mass of material in storage exceeds the amount in process daily. Large scale storage operations are typically occupied only a fraction of the work day. Ventilation in storage facilities is likely to be at a lower air change rate when compared to ventilation in a processing facility where vigorous mechanical or chemical processes are conducted. ORAUT-TBKS-017-5, Rev 3, Table B-5 "Summary of thoron exposure estimates" shows, in the last two rows various storage sites throughout the site's history contained as much as 300 MT ($300*10^6$ g) of thorium. Using a value of $0.989*10^5$ pCi/g, there could be $3*10^{13}$ pCi of Th-232 in storage.

   The thorium in storage was chemically purified at some time prior to storage. That created a disequilibrium between Th-232 activity and Th-228 activity, which would be a variable as a function of time, initially decreasing and then increasing several years later. The time since chemical separation is not known, but the assuming only one chemical separation occurred the disequilibrium cannot be less than 65%, or more than 100%. Since 100% is a bounding assumption, that value is selected. It follows that the bounding activity of Th-228 in storage, and its short-lived the decay product, thoron, will be $3*10^{13}$ pCi.

   A release fraction for the thoron in storage must be assumed. Release of the inert noble gas thoron under storage conditions occurs by a diffusion process. The short half-life of thoron (56 s) limits the amount of diffusion that can occur before the element loses its noble gas property and diffusion stops. This means that release fractions for material in storage tend to be small. Assuming a relatively large release fraction value of $1*10^{-4}$, the airborne thoron activity in a large storage facility is $3*10^8$ pCi. The estimated volume of the airspace in an FMPC storage building is $1*10^7$ L, so the thoron air concentration is 300 pCi/L.

   The Potential Alpha Energy Concentration (PAEC) described in Table B-3 shows that there is $1.33*10^5$ MeV/L per 7.5 pCi/L of thoron. PAEC can be expressed in Working Level, where 7.5 pCi of thoron in equilibrium with the short-lived decay products equals one Working Level. A 300 pCi/L concentration of thoron in equilibrium with its short-lived decay products is 40 WL.

   In a 2006 paper, Harley and Chittaporn reported that the indoor thoron equilibrium factor, F_{eq}, is likely to be 0.02 and cannot exceed 0.04. F_{eq} describes the activity relationship between thoron and its short-lived decay products which contribute to respiratory tract dose. F_{eq} can be used as a factor to modify Working Level. Using a value of F_{eq} of 0.04, the Working Level is 0.16. Assuming an occupancy factor in the storage facility of 25% (three work months per work year) the thoron exposure potential is 0.4 WLM per year.

2. The following information provides a better explanation of how default values for thoron exposure in Building 65 is estimated:

A thoron concentration of 267 pCi/L was measured in Building 65 during the first calendar quarter of 1996 as reported in Renk (1998, page 65, SRDB Ref ID: 133254) using a track-etch device. This was by far the highest reported result in that large data set. Although it is an outlier in the context of the average measurement for that period at FMPC, it probably is an accurate indicator of the thoron concentration in that building.

The Potential Alpha Energy Concentration (PAEC) described in Table B-3 shows that there is $1.33*10^5$ MeV/L per 7.5 pCi/L of thoron. PAEC can be expressed in Working Level, where 7.5 pCi of thoron in equilibrium with the short-lived decay products equals one Working Level. A 267 pCi/L concentration of thoron in equilibrium with its short-lived decay products is 35.6 WL.

In a 2006 paper, Harley and Chittaporn reported that the indoor thoron equilibrium factor, F_{eq}, is likely to be 0.02 and cannot exceed 0.04. F_{eq} describes the activity relationship between thoron and its short-lived decay products which contribute to respiratory tract dose. F_{eq} can be used as a factor to modify Working Level. Using a value of F_{eq} of 0.04, the Working Level is 1.42. Assuming an occupancy factor in the storage facility of 25% (three work months per work year) the thoron exposure potential is 0.36 WLM per year.

Considering that this measured value represented only one calendar quarter out of many, it is unlikely that this is a bounding analysis of the thoron exposure potential in Building 65. A bounding analysis might be expected by increasing the thoron exposure by 50%. This results in a rounded value of 0.5 WLM per year.

3. The value used to describe the disequilibrium between Th-232 and Th-228 could be any number less than 100%. Triple-separated thorium, with its equilibrium value of 23%, was selected for use when interpreting in vivo lung counting data because in that context a lower value is more favorable to the claimant than a higher value. In the context of thoron exposure based on air concentration of radioactive material, a higher equilibrium value is more favorable. For this calculation a value of 100% is chosen as a bounding and claimant-favor assumption.

4. The value, F_{eq}, used to describe the equilibrium between thoron (Rn-220) and its short-lived decay products is used to modify the Working Level calculated with the assumption of 100% equilibrium. Values of F_{eq} could range from less than 1% to 100%. Higher thoron exposures result from higher values of F_{eq}. Empirically, F_{eq} has been observed to be very low, only a few percent. In a 2006 paper, Harley and Chittaporn reported on the indoor thoron equilibrium factor and included data from FMPC in the analysis. They concluded that 0.04 was a bounding value.

5. A release fraction for the thoron from solid thorium metal or sol-gel must be assumed. Release of the inert noble gas thoron under storage conditions occurs by a diffusion process. The short half-life of thoron (56 s) limits the amount of diffusion that can occur before the element loses its noble gas property and diffusion stops. This means that release fractions for material in storage tend to be small. We believe that a bounding value for this factor is $1*10^{-4}$. When this value is assumed the thoron exposure calculated in item 1 (above) matches well with the empirically observed thoron exposure shown in item 2 (above).

6. The thoron exposure for the "Passive storage" period, 1986 through 1987, will be changed to match the thoron exposure assigned during the "Long-term DOE repository storage" period.

7. In summary, we recommend that 0.5 WLM/y can be used as a bounding estimate of thoron exposure for all years and all locations for those claimants who are potentially exposed.