Fernald SEC Petition Review

Focused SC&A Status Update: SEC Issue 6B – Use of Chest Counts to Reconstruct Th-232 Intakes (1968–1978)

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Presented to the Advisory Board on Radiation and Worker Health

Full Board Meeting Teleconference

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Open Issue (#6B) Use of Chest Counts to Reconstruct Th-232 Intakes (1968–1978)

Description of Issue 6B - Review

- No DWE data after MIVRML introduced in 1968 – therefore completely dependent on integrity of chest count data thereafter
- 1968–1978 – results reported in mass units (milligrams thorium) with no raw data
- 1979–1988 – results reported in activity of progeny (nCi Pb-212 and Ac-228)

Status of issue

- White papers exchanged; issue discussed in detail at April 19, 2011; August 11, 2011; and February 9, 2012, WG meetings.
- Full Board meeting – February 2012
  - SC&A Position: **1968–1978** data reported in milligrams thorium likely inadequate for DR (SEC)
    1. Large uncertainties related to how the mg thorium data were derived (potentially underestimated actual by factor of 100; overestimated background level by 1,000)
    2. "Technical shortfall" issue (deferred: program-wide issue of "sufficient accuracy" under review by SEC Issues Subcommittee)

Issue #6B: Use of Chest Counts to Reconstruct Th-232 Intakes (1968–1978)

- February 2012 (before Board meeting) – NIOSH posts set of documents claimed to be *"relevant references related to the estimation of thorium-232 [Th-232] intakes for Fernald workers using in vivo data from the Y-12 mobile counter (MIVRML)"*
  - NIOSH white papers and other documents that describe different approaches that could have been used to calculate Th-232 lung for 1968–1978
- SC&A response delivered April 6, 2012, *"Summary of SC&A Concerns Regarding the Latest Documents Posted by NIOSH to Complement their White Papers on In-vivo Thorium Bioassay"*
  - Conclude – NIOSH white papers based on unsupported assumption that Pb-212 was measured and Th-232 burdens in mg were calculated using those measurement results

Issue #6B: Use of Chest Counts to Reconstruct Th-232 Intakes (1968–1978)

- Inconsistencies between mg Th-232 and nCi Pb-212 for period of overlap (1978, 1979) suggest that Pb-212 was not used to derive mg Th-232 (next slide)
  - Three highest mg Th-232 correspond to negative Pb-212 results
  - Nine values in 1979 reported as 2.1 mg but Pb-212 ranged from 0.19 to 0.40 nCi and Ac-228 from 0.33 to 0.7 nCi. These data are suspect. Only 1 Pb-212 result was less than the stated MDL of 0.23 nCi (1987).
  - **Expect proportionality between Th-232 and progeny in 1979 data (divided by plant work and by dates) because the source was probably the same.**
  - **Results highlighted green**: workers co-located and measured in June, yet results of Pb-212 varied from 0.25 to 0.40 nCi with the same result in mg of Th-232.
  - **Results highlighted pink**: workers in Plant 4 monitored in October, yet results varied from 0.19 nCi of Pb to 0.40 nCi, with the same result in mg of Th-232.

Issue #6B: Use of Chest Counts to Reconstruct Th-232 Intakes (1968–1978)

Reported Thorium Result (mg)	Reported Pb-212 Activity (nCi)	Reported Ac-228 Activity (nCi)	Monitoring Date	Location or Plant #
-5.00	-0.04	-0.02	8/29/1974	7 or Pilot
-0.60	-0.08	0.03	06/08/88	Maintenance
-0.54	-0.18	-0.01	06/12/86	5
-0.16	-0.16	-0.09	06/23/87	5
-0.12	0.06	0.01	07/10/73	6
-0.05	-0.05	0.02	05/02/87	Maintenance
-0.01	-0.01	0.05	12/09/86	No Information
0.01	-0.06	-0.08	05/02/77	Mech
0.30	0.15	0.06	04/06/77	6
1.81	-0.10	0.04	08/09/85	5
2.10	**0.25**	**0.35**	**06/02/79**	**7 or Pilot**
2.10	**0.30**	**0.5**	**06/09/79**	**7 or Pilot**
2.10	**0.40**	**0.7**	**06/12/79**	**7 or Pilot**
2.10	**0.40**	**0.65**	**06/19/79**	**7 or Pilot**
2.10	**0.40**	**0.5**	**10/08/79**	**4**
2.10	**0.19**	**0.33**	**10/22/79**	**4**
2.10	**0.27**	**0.33**	**10/29/79**	**4**
2.10	**0.28**	**0.41**	**10/17/79**	**4**
2.10	**0.29**	**0.39**	**10/15/79**	**4**
2.20	**-0.10**	**-0.1**	**04/13/77**	**Mech**
4.30	**-0.04**	**0.05**	**04/26/71**	**Inspection**
5.10	**-0.04**	**0.01**	**06/04/80**	**Mech**

Source: Table 1. SC&A Final Position on the Th-232 In-vivo Data Quality and Adequacy for FEMP Workers

Issue #6B: Use of Chest Counts to Reconstruct Th-232 Intakes (1968–1978)

- April 9, 2012 – NIOSH posts PowerPoint presentation titled, ***"Bounding Thorium-232 Intakes Using MIVRML Data,"*** and reference summary to support their position
  - March 15, 2012 – NIOSH Interviewed L. Max Scott, PhD., Principal designer and developer of the MIVRML (Board and SC&A not notified)
    - MIVRML patterned after fixed Y-12 system and calibrated and operated in exactly the same manner as the fixed system
      - Same calibration standard used for both systems: Th-232/Ra-228 = 1.67 (60% equilibrium); Th-232/Th-228 = 1.27 (80% equilibrium)
        - Note : these ratios are not possible for a single purified thorium source. Indicates Ra-228 contamination.
      - REMAB phantom
      - 20 minute counts
      - Used empirical "sum of ratios" method to derive mg values (next slide)
  - NIOSH position unchanged
    - Thorium mass reporting methodology is not an SEC issue
    - Thorium intakes estimated from MIVRML measurements are plausible, claimant favorable, and bounding

Issue #6B: Use of Chest Counts to Reconstruct Th-232 Intakes (1968–1978)

MIVRML Empirical Equation for Calculating Mg Thorium Values

$$mg_{Th} = \left(\left(\frac{ROI_{0.208-0.248}}{ROI_{0.249-0.295}} + \frac{ROI_{0.299-0.395}}{ROI_{0.396-0.547}} + \frac{ROI_{0.775-0.930}}{ROI_{0.931-1.077}} \right) - 3.23 \right) * 8.84$$

- Based on Y-12 method and "Rule of Thumb" document (letter from L. Max Scott to C.M. West dated November 21, 1961)
- Where "ROI" is the total count in a region of interest. For example:
  - $ROI_{0.208\text{-}0.248}$ is the count in the portion of the spectrum between 0.208 MeV and 0.248 MeV (from Pb-212) and
  - $ROI_{0.249\text{-}0.295}$ is the "background" count in the adjacent higher energy portion of the spectrum between 0.249 MeV and 0.295 MeV
- 3.23 (3.23 ± 0.7) is an average value of summed ratios of counts in the three ROIs obtained for about 1,100 non-exposed persons (Table 1, Scott 1966)
  - Variation (3.23 ± 0.7) represents 95th percentile confidence interval
- 8.84 is a coefficient to convert the summed ratios to units of mass (milligrams thorium)
  - Specific to the calibration source and conditions at Y-12

Issue #6B: Use of Chest Counts to Reconstruct Th-232 Intakes (1968–1978)

Sample spectra for exposed and non-exposed workers showing ROIs and adjacent higher energy “background” regions (West 1965)

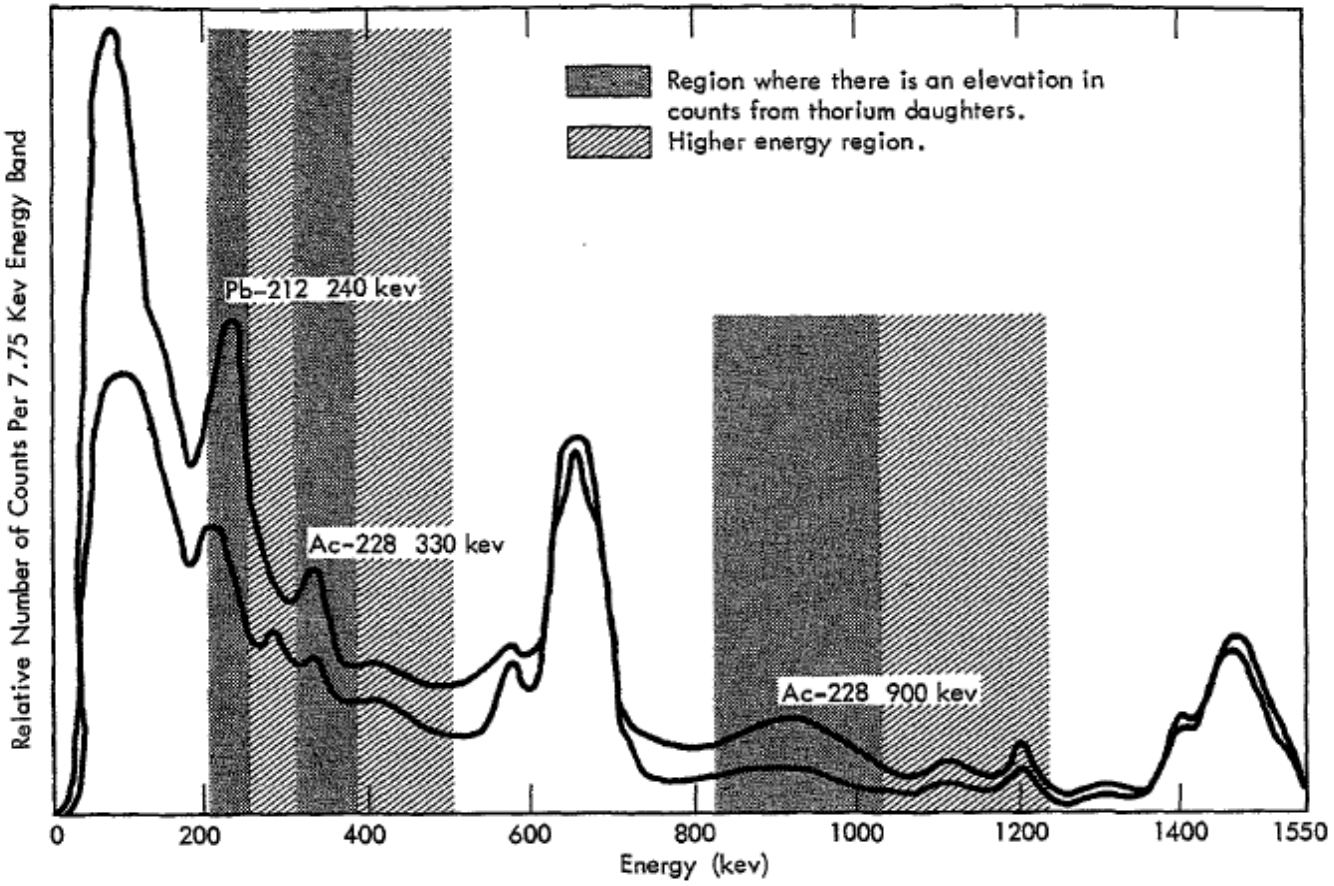

Figure 13. SCHEMATIC REPRESENTATION OF THE THORIUM IN VIVO SCREENING TECHNIQUE.

Issue #6B: Use of Chest Counts to Reconstruct Th-232 Intakes (1968–1978)

April 17, 2012 – SC&A responds to NIOSH presentation with a memo titled, *"SC&A Comments on Slide 7 of NIOSH Presentation"*

- "Thorium coefficient" of 8.84 is an empirical value that converts the dimensionless sum of ratios to thorium mass for the sources and conditions of calibration at Y-12, as indicated in the "Rule of Thumb" document (letter from L. Max Scott to C.M. West dated November 21, 1961)
  - *Health Physics Considerations Associated with Thorium Processing* (West 1965) states that a rise in the ratio of 1 is equivalent to 33% of the lung burden of the listed mixture. Indicates applicability to the particular mixture of daughters of the source he was using.
  - "Rule of Thumb" document does not explain how the coefficient was derived or its limitations as a screening tool
  - Coefficient varies depending on the equilibrium rates from Th-232 and daughters for the sources comprising the lung burden in any given worker
- MDA issue: mean sum of ratios of 3.23 for non-exposed persons has a variation of 0.7
  - Used to derive the "MDA" for Th-232 in the lung (6 mg). All results between -0.7 and 0.7 * 8.84 (-6 mg to 6 mg), produce values within the variation of the population, with a mean of 0
  - Stated MDA of 6 mg is an empirical value - not based on the counting statistics of the MIV system

Issue #6B: Use of Chest Counts to Reconstruct Th-232 Intakes (1968–1978)

April 17, 2012 – SC&A response (continued)

- **SC&A hypothetical example using "Rule of Thumb" method**: Worker exposed to Type M thorium source for 60 days then monitored on the MIVRML. Assume he was monitored in the year he was working with thorium, on one of these dates:
  - The middle of his exposure period (30 days after the first day of exposure)
  - The last day of exposure
  - 90 days, 120 days, 180 days or 360 days after first day of exposure
  - Assume 0.23 nCi Pb-212 and 0.24 nCi Ac-228 (post-1978 values)
- **If 10 mg measured, daily intake ranges from 17 to 137 Bq**
- **If source in equilibrium**, Pb-212 and Ac-228 = 1.1 nCi on all dates and sum of the counts in all three regions of the Pb-212 and the Ac-228 peaks would be higher than background
- **Triple purified (NIOSH worst-case assumption**) → large disequilibrium ratio of Th-232 to Th-228 (1:0.19): activities of Pb-212 and Ac-228 corresponding to 10 mg lung burden NOT distinguishable from background
- **Single purification:** Activities of Pb-212 in the lung corresponding to 10 mg Th-232 lung burdens would vary from 0.81 to 1.0 nCi. The activities of Ac-228 in the lung corresponding to 10 mg Th-232 lung burdens vary from 0.003 to 0.0674 nCi, all below detection limits.
  - Only peak region that has higher counting than from non-exposed people is the Pb-212 peak
- **In reality, there is no hook back to Pb-212 activity**. We don't know the count ratios, and the thorium conversion factor (8.84) depends on the conditions of system calibration and cannot be adjusted for other sources.

Issue #6B: Use of Chest Counts to Reconstruct Th-232 Intakes (1968–1978)

April 17, 2012 – SC&A response (concluded)

- Three main issues remain concerns to SC&A:
  - The sum of ratios can potentially miss very large intakes, depending on the number of purifications and the age of the source since separation.
  - The thorium coefficient of 8.84 is narrowly defined for a set of conditions unique to Y-12 and is not transferrable to FMPC or any other facility.
  - Th-232 was present at FMPC in both soluble Type M (TNT) and insoluble Type S (oxide and metal) materials. Ra-228 produced in a Type S matrix leaves the lung more rapidly than thorium and exhibits properties closer to Type M. These physico-chemical disparities are not captured by the sum of ratios screening method.
- Lack of Coherence between Slide 6 and Slide 7
  - Slide 6 of the presentation proposes the use of a correction factor of 5.25 to be applied to measured results. This factor of 5.25 was derived assuming that Pb-212 was measured, and that the Pb-212 result was used to derive the mg of Th-232 results. The same correction factor is not applicable to the empirical method described in slide 7.
- **In summary**, if the empirical equation in slide 7 of the NIOSH presentation was applied without modifications to account for the source terms encountered at FMPC, then the mg Th-232 results were not derived correctly and carry huge uncertainties that cannot be reconciled.
- SC&A believes that the thorium lung burdens reported in units of mg from 1968–1978 cannot be reconstructed or associated with meaningful intakes and, therefore, it does not appear possible to place a scientifically sound and plausible upper bound on the thorium body burdens for some workers.

Issue #6B: Use of Chest Counts to Reconstruct Th-232 Intakes (1968–1978)

April 19, 2012 – Work Group Teleconference

- NIOSH presents position (slides and references) and SC&A responds (as stated herein)
- Work Group discussion
  - Issues with "Rule of Thumb" sum of ratios method
    - Only mg value reported; counts and/or ratios not reported or available.
    - Coefficient for converting dimensionless sum of ratios to mg value varies for every potential source. Therefore, 8.84 cannot be applied to sources at FMPC.
    - Unknowns in the empirical equation as applied to FMPC sources include: ratios and sum of ratios for exposed workers, source-specific conversion coefficient(s), background sum of ratio distribution likely different for MIVRML (higher background) – cannot "deconvolute."
    - Lung burdens in the 10's of mg could have been missed altogether (SC&A example).
  - SC&A Table 1 showing Pb-212 and Ac-228 values >MDA are not proportional and are not proportional to stated mg values (Slides 4 and 5)
  - High values followed by very low values do not comport with known biokinetic processes
  - Given the current state of knowledge regarding the methods employed and the lack of available raw data (ROI counts, efficiencies, source characteristics), the **Work Group does not believe that a plausible upper bound can be applied to the mg thorium data for the period 1968–1978**

Questions?