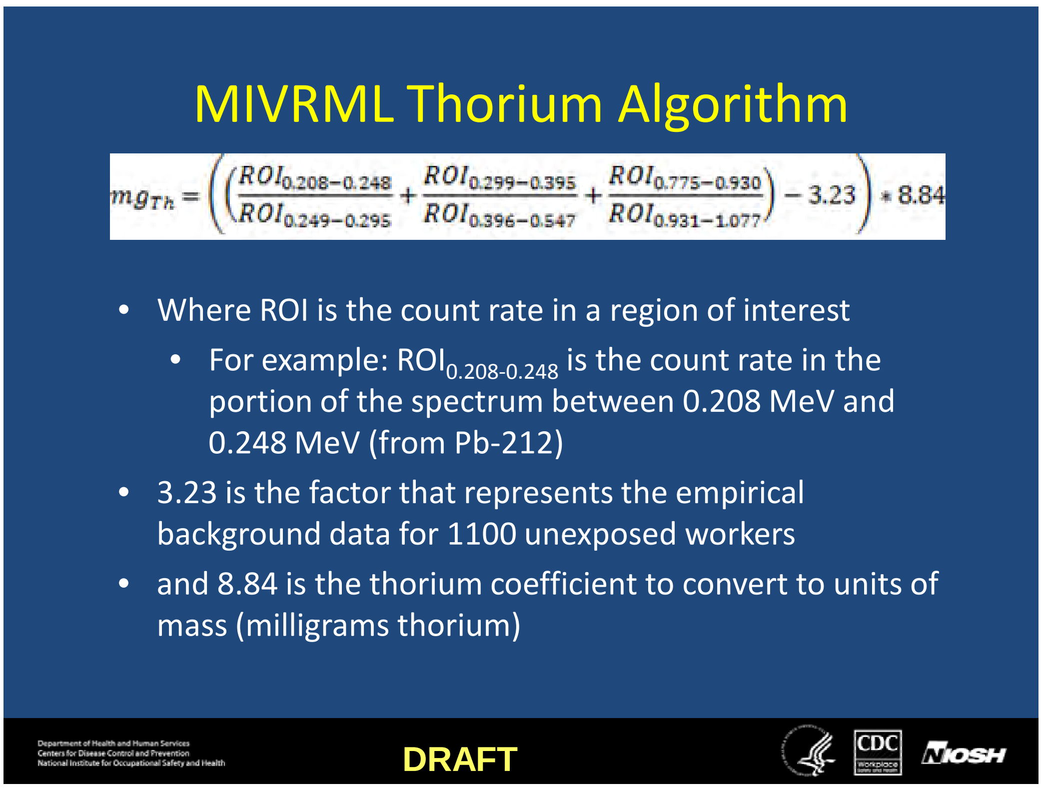
SC&A, inc.

MEMO

TO: Fernald Work Group
FROM: Joyce Lipsztein and John Stiver, SC&A
DATE: April 17, 2012
SUBJECT: SC&A Comments on Slide 7 of NIOSH Presentation

Some Comments on NIOSH Presentation delivered to the Fernald Work Group April 9, 2012.

Slide 7 from NIOSH Presentation:



There is no scientific basis for the equation presented on the slide above. It is an empirical equation derived for the lung measurement results of a specific thorium source used for calibrations at Y-12 and was intended to be used only for screening.

- The value 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. It was derived for the fixed whole-body counter at Y-12. The ratio for non-exposed persons is dependent on and strongly influenced by the counting room background. The background of the Mobile In-Vivo Radiation Monitoring Laboratory (MIVRML) was higher than the background at the fixed facility. There are no scientific papers showing that the value of 3.23 ± 0.7 is appropriate and applicable for people measured in a higher background counting room.

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- The sum of the counts under the Pb-212 and Ac-228 peak areas is strongly dependent on the amount of Pb-212 and Ac-228 in the source material, which in turn depends on the age of the source since chemical separation (degree of disequilibrium between parent and progeny).

Example:

Let's assume that a worker was exposed to Type M thorium source for 60 days and that he was monitored at the MIVRML. Let's 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
- Minimum Detectable Activities (MDA) in units of nanocuries (nCi) for Pb-212 and Ac-228 were not reported for the mg thorium data. For illustrative purposes, this example applies the MDAs reported for Pb-212 and Ac-228 post-1978.

If the lung burden of Th-232 was 10 mg at 30 days after the first day of exposure, his daily intake would have been 28.7 Bq. If the lung burden of Th-232 was 10 mg at 60 days after the first day of exposure, his daily intake would have been 17 Bq. If the lung burden of Th-232 was 10 mg at 90 days after the first day of exposure, his daily intake would have been 23 Bq. If the lung burden of Th-232 was 10 mg at 120 days after the first day of exposure, his daily intake would have been 30 Bq. If the lung burden of Th-232 was 10 mg at 180 days after the first day of exposure, his daily intake would have been 47 Bq. If the lung burden of Th-232 was 10 mg at 360 days after the first day of exposure, his daily intake would have been 137 Bq.

(1) If the worker was exposed to a thorium source in equilibrium with the daughters, the activity of both Pb-212 and Ac-228 would have been equal to 1.1 nCi (40.5 Bq or 2,430 dpm) on all monitoring dates. Thus, the sum of the counts in the regions of the Pb-212 and the Ac-228 peaks would be higher than background in all three regions.

(2) If the worker was exposed to thorium material that went through three chemical separations (NIOSH's worst-case scenario) producing a large disequilibrium ratio of Th-232 to Th-228 (1:0.19), then the activities of Pb-212 in the lung corresponding to 10 mg Th-232 lung burdens would vary from 0.16 to 0.198 nCi, all below detection limits indicated for post-1978 (MDA equals 0.23 nCi). The activities of Ac-228 in the lung corresponding to 10 mg Th-232 lung burdens would vary from 0.005 to 0.11 nCi, all below detection limits indicated for post-1978 (MDA equals 0.24 nCi). As activities of Pb-212 and Ac-228 are both below the MDA, it would not be possible to distinguish the counts in the regions of interest (ROIs) of Pb-212 and of the two ROIs of Ac-228 of the workers from the counts of non-exposed persons. The result of the equation would lead to a conclusion that the workers were not exposed, instead of indicating a lung burden of 10 mg.

(3) If the worker was exposed to thorium material that went through a single chemical separation, immediately after separation, when the only isotopes present are Th-232 and Th-228 in equal activities but without the presence of daughters, the 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 6 mg Th-232 lung burdens would vary from 0.003 to 0.0674 nCi, all below detection limits (MDA equals 0.24 nCi). Activities of Ac-228 are below the MDA, and thus it is not possible to distinguish the counts in the two ROIs of Ac-228 of the workers from the counts of non-exposed persons. The only peak region that has higher counting than from non-exposed people is the Pb-212 peak. The equation described in Slide 7 cannot be used directly as posted.

- The "thorium coefficient" of 8.84 is an empirical value that lacks a technical explanation, yet is the linchpin that translates 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). It cannot be applied directly to FMPC, or for that matter to most Y-12 exposures, because the coefficient varies depending on the equilibrium rates from Th-232 and daughters for the sources comprising the lung burden in any given worker. The Rule of Thumb that NIOSH cites as "the algorithm used to calculate the thorium mass results from the MIVRML measurement data" does not explain how the coefficient was derived or its limitations as a screening tool. In the West paper, *Health Physics Considerations Associated with Thorium Processing* (West 1965), it is stated that a rise in the ratio of 1 is equivalent to 33% of the lung burden of the listed mixture. West does not explain how the 33% of the lung burden was derived, but he points to its applicability to the particular mixture of daughters of the source he was using.

- In addition, the mean sum of ratios of 3.23 for non-exposed persons has a variation of 0.7. This variation was used to derive the "MDA" for Th-232 in the lung (6 mg). Thus, all results between -0.7 and 0.7 multiplied by the 8.84 (-6 mg to 6 mg), would produce values within the variation of the population, with a mean of 0. It is important to note that this is not a true MDA based on counting statistics, as is the customary accepted practice in health physics. The "MDA" range of values as seen above would greatly underestimate a true exposure of 10 mg, as seen in the second scenario above (three chemical separations). It is not possible to give an upper value to this underestimation; much larger intakes could have been missed all together. On the other hand, if the worker was not exposed, his lung burden would be within the range of µg of Th-232 in the lung and some values could be an overestimation of the Th-232 burdens by 2 to 3 orders of magnitude.

- Three main issues remain concerns to SC&A. First, the sum of ratios method depicted in Slide 7 can potentially miss very large intakes, depending on the number of purifications and the age of the source since separation. Second, 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. Third, 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:

- In addition, 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, that would account for the source terms encountered at FEMP; the mg of Th-232 results were not derived correctly and carry huge uncertainties that cannot be reconciled. Thus, SC&A's position regarding the veracity of the mg thorium chest count data, as articulated in the recent memorandum titled, *Summary of SC&A Concerns Regarding the Latest Documents Posted by NIOSH to Complement their White Papers on In-Vivo Thorium Bioassay* (SC&A 2012), remains unchanged.

REFERENCES

SC&A 2012. *Summary of SC&A Concerns Regarding the Latest Documents Posted by NIOSH to Complement their White Papers on In-Vivo Thorium Bioassay*, Response to NIOSH white paper prepared for the Advisory Board's Fernald Work Group. SC&A, Inc., Vienna, Virginia. April 6, 2012.

Scott, L.M., 1961. Letter from L.M. Scott (Union Carbide) to C.M. West (Union Carbide): *Rule of Thumb for Computing Thorium Body Burdens from In-Vivo Counts*, *November 21, 1961*, Document Capture No. Y/AB-NIOSH-2007-046. SRDB 32615.

West, C.M., 1965. *Health Physics Considerations Associated with Thorium Processing*, Report Number Y-KB-53, Union Carbide Corporation, Nuclear Division, Oak Ridge, Tennessee, Y-12 Plant, 1965. SRDB 11596.