Bounding Thorium-232 Intakes Using MIVRML Data

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NIOSH Can Bound Thorium-232 Intakes

- Sufficient data are available – a coworker model has been developed using > 5000 MIVRML thorium chest count results
- Chronic thorium-232 intake retention fractions have been derived which account for differential biokinetics of decay products
- Sample intake and dose calculations were completed to demonstrate the methodology

All Issues Have Been Researched

- NIOSH investigated where, when, and why the Mobile *In Vivo* Radiation Monitoring Laboratory technology was developed
- MIVRML calibration and operating procedures
  - Techniques and calibrations of the MIVRML were identical to the Y-12 stationary whole body counter
- Who was selected for chest counting and why
- Reporting and interpretation of the MIVRML results

Calibration

- Calibration of MIVRML used a REMAB phantom
- Thorium calibration standards had a $^{232}Th/^{228}Th$ ratio of 1.27 and a $^{232}Th/^{228}Ra$ activity ratio of 1.67.
  - The lower limit of detection for such material is 6 milligrams.
- Thorium chest burdens were reported in milligrams rather than nanoCuries, based upon the established reporting protocols for uranium at the Y-12 counting facility

Progeny Measurements

- Thorium-232 chest burdens derived from measurements of deposited progeny:
  - 240 keV ϒ-ray from Lead-212, plus the 330 and 900 keV ϒ-rays from Actinium-228 were measured allowing the mass of thorium to be determined via the established Y-12 technique of using ratios of the count rates from adjacent Regions of Interest in the spectra

Measurement Adjustments

- Age of the thorium material involved in historical exposure scenarios is assumed to be unknown
- Chemical separation and purification of thorium disturbs the equilibrium of th-232 and progeny
  - For bounding intake estimation by NIOSH, three chemical separations of the thorium material are assumed in order to produce the largest disequilibrium ratio of thorium-232 to thorium-228 (1 : 0.19)
  - Correction factor of 5.25 applied to measured results

MIVRML Thorium Algorithm

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

- Where ROI is the count rate in a region of interest
  - For example: $ROI_{0.208\text{-}0.248}$ is the count rate in the portion of the spectrum between 0.208 MeV and 0.248 MeV (from Pb-212)
- 3.23 is the factor that represents the empirical background data for 1100 unexposed workers
- and 8.84 is the thorium coefficient to convert to units of mass (milligrams thorium)

Summary

- NIOSH and ORAU whole body count experts have reviewed and approved the approach for bounding thorium intakes and doses to workers.
- Thorium mass reporting methodology is not an SEC issue
- Thorium intakes estimated from MIVRML measurements are plausible, claimant-favorable, and bounding