Review of ORAUT-RPRT-0084 for Two-Count Filter Method for Measurement of Thoron Progeny in Air

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ORAUT-RPRT-0084 purpose

- Evaluate a method to calculate internal dose to the lungs from inhalation of thoron (Rn-220) and its progeny using Bi-212 and Pb-212
  - Thoron is an alpha-emitting gaseous radioactive material produced through radioactive decay of Th-232
- RPRT-0084 provides a process for deriving an equation to calculate the concentration of long-term thoron progeny using a two-count filter method
- The two-count filter method to calculate the Pb-212 concentration in the ambient air is as follows:
  - Pull air through a filter for 6 hours and measure the total alpha activity on the filter after the pump stops
  - Pull air through the same filter for an additional 18 hours and measure the total alpha activity on the filter after the pump stops

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RPRT-0084 overview

- ◆ A two-fold approach was used to calculate the concentration of Pb-212 in air to indirectly calculate internal dose from inhalation of thoron and its progeny

- ◆ Members of the thoron decay chain are as follows:
  - – Rn-220: t_H (half-life) = 55.6 sec (alpha decay)
  - – Po-216: t_H = 0.15 sec (alpha decay)
  - – Pb-212: t_H = 10.64 hrs (beta decay)
  - – Bi-212: t_H = 60.6 min (36% alpha decay, 64% beta decay)
  - – Po-212: t_H = 304 nsec (alpha decay)
  - – TI-208: t_H = 3 min (beta decay)

- ◆ Bi-212 and Pb-212 are the primary radionuclides of interest when calculating the internal dose

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RPRT-0084 approach to deriving an equation for the two-count filter method

Forward problem approach

Calculate total alpha activity expected on the filter paper when it is counted at 6 and 24 hours after the air sampler pump is turned off using known concentrations of Pb-212, Bi-212, and a long-lived alpha emitter in air.
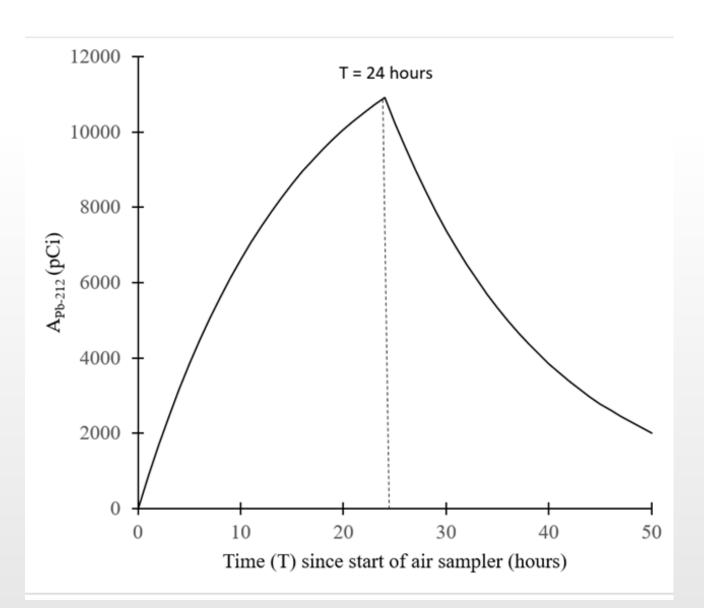
Reverse problem approach

Derive an equation to calculate the concentration of Pb-212 in ambient air using the total alpha activity determined in the forward problem approach.

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RPRT-0084 forward problem approach methodology

- The concentration of the source term is assumed to be a constant stream of Pb-212 and Bi-212 released into the air sampler

- The forward problem approach calculates the total alpha activity on the filter at 6 and 24 hours after the sampler pump is turned off

- NIOSH assumed Pb-212 in air going into the sampler to be 1 pCi/L

- The flow rate of the sampler was 15 L/minute = 900 L/hour

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Pb-212 activity on filter paper as function of time

The Pb-212 activity builds exponentially from the time the air pump is turned on to the time it is turned off at 24 hours, and then decays exponentially.

RPRT-0084 forward problem approach for assessing activities of Pb-212 and Bi-212

- **Pb-212:**
  - From the initial deposition of Pb-212 on the filter paper at T = 24 hours, the decayed Pb-212 filter paper activities were calculated for 6 hours (T = 30 hours) and 24 hours (T = 48 hours) after the pump stopped

- **Bi-212:**
  - Activities were assumed to be in transient equilibrium with the Pb-212 activities after the pump stopped
  - Activities of Bi-212 at 6 and 24 hours after the pump stopped can be determined from the decayed Pb-212 activities on the filter paper calculated for 6 and 24 hours by multiplying them with the Bi-212 to Pb-212 activity ratio

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RPRT-0084 forward problem approach to calculating alpha activities

- Bi-212 to Pb-212 activity ratio is equal to the Bi-212 decay constant divided by the difference of Bi-212 and Pb-212 decay constants

- Bi-212 emits alpha particles; therefore, Bi-212 activities at 6 and 24 hours after the pump stopped were used to determine total alpha activities on the filter paper at 6 and 24 hours

- Alpha activities determined at 6 and 24 hours were used as input parameters in an equation derived in the reverse problem approach to calculate the concentration of Pb-212 in air

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◆ Final Pb-212 concentration equation derived in the reverse problem approach:

$$C_{pb} = \left[\frac{\lambda_{bi} - \lambda_{pb}}{\lambda_{bi}}\right]\left[\frac{A_{24} - A_6}{e^{-\lambda_{pb}24} - e^{-\lambda_{pb}6}}\right]\left|\frac{\lambda_{pb}}{F(1 - e^{-\lambda_{pb}T})}\right|$$

◆ The alpha activities determined at 6 and 24 hours (i.e., A6 and A24) in the forward problem approach are used as input parameters into this equation

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RPRT-0084 conclusions about derived Pb-212 concentration equation

- The equation was solved by entering input parameters as follows:
  - Alpha activities determined at 6 and 24 hours in the forward problem approach
  - Pb-212 and Bi-212 decay constants
  - Flow rate of the sampler

- The resulting Pb-212 concentration in the sampled air was equal to 1 pCi/L

- This confirmed that that the derived equation in the reverse problem approach is appropriate for calculating the Pb-212 concentration in the sampled air

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SC&A's review of RPRT-0084

- SC&A did not identify any issues with the general NIOSH approach to evaluate the two-count filter method for measurement of thoron progeny in air

- SC&A evaluated the two-count filter method employed by NIOSH to analytically estimate the Pb-212 concentration in the ambient air

- SC&A evaluated both the forward and reverse problem approaches to estimate the Pb-212 concentration in the ambient air

- SC&A verified NIOSH's statement that the total alpha activity is not a parameter of interest when calculating Pb-212 concentration in the ambient air
  - That is, the total alpha activity is an independent variable when calculating Pb-212 concentration in the ambient air

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Summary of SC&A's review of RPRT-0084

- SC&A found the approach used to develop a sampling plan to be reasonable and technically correct

- SC&A found the analytical methods used in the forward and reverse problem approaches to be acceptable

- SC&A provided some expanded discussion concerning the effects that changes in variable parameters could have on the results

- SC&A did not identify any documentation issues that would affect the readability or application of the two-count filter method

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Questions?

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