Method for Estimating Thorium Activity in the Body Using a Thoron-In-Breath Monitor

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Routine thorium bioassay monitoring is typically done using one or a combination of in vivo counting, sampling urine, sampling feces, and air sampling. Minimum detectable activities less than or equal to the Th-232 or the Th-228 annual limit on intake (especially for Class Y) are not always achievable using these methods. A thoron-in-breath monitor (TIBM) was developed to provide an alternative method for routine monitoring of thorium in workers. A 17.5-liter chamber used for radon detection was modified for measuring thoron in exhaled breath. From previous work it was known that a measurement device that could detect an ALI or less should be achievable using a TIBM. Calibration of the TIBM is performed by passing air at a known flow rate over a Th-228 source to generate known thoron concentrations that enter the chamber. Because the TIBM collection efficiency can be dependent on the relative humidity of the air a desiccant column is used to dry the air stream before it enters the TIBM. Exhaled breath from subjects is collected for 20 minutes in the chamber that has a B5.6 kV potential on the collecting electrode. At 8 liters per minute, 80% of the thoron decays in the TIBM chamber. The charged progeny are collected on a zinc sulfide (ZnS) filter. A 4 pi counting geometry is approximated by placing the ZnS surface of the filter in contact with the ZnS surface of a second filter. The scintillations from the alpha particle interactions are counted for a minimum of 20 hours. The gross alpha counts in the 4-hour to 20-hour interval are summed and divided by the thoron activity that entered the chamber to determine the calibration factor. The minimum detectable activity of thoron using this technique is 1.6 Bq.

A six-stage biokinetic model that treats the radium and thorium metabolism separately is used to estimate the Th-232 activity from the measured amount of thoron. The model output provides the thoron exhalation rate as a function of the time after intake for specified intake conditions. Particle size, mode of intake (i.e. acute vs. chronic), length of chronic exposure, degree of equilibrium and exertion level can be specified by the user. The model also allows the user to estimate the Th-232 intake based on Ac-228 activity in the chest for comparison with in vivo counting results. A minimum detectable intake (MDI) of 130 Bq at 365 days after an intake of a 1 micron Class Y aerosol was calculated for Th-232 in equilibrium with Th-228. The MDI is based on measurements of 23 subjects with no known occupational exposure to thorium. Individuals with measurable thorium depositions using standard in vivo counting techniques are being sought to validate the TIBM results.

Pending validation of the TIBM technique, the TIBM will provide a useful tool for occupational monitoring of workers employed in industry and research that involves exposure to respirable aerosols of thorium. The TIBM can be brought to the workplace, has an MDI that is equal to or lower than in vivo and in vitro sampling techniques. The results from the TIBM measurements are available within one day. The measurement process requires the worker to sit and breath into a medical grade facemask for 20 minutes. One of the 23 background subjects was only able to provide a 10-minute sample because they were uncomfortable wearing the facemask.