

Use of Mobile Counter Thorium Mass Results as a Bounding Estimate  
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Thorium daughters can exist in varying degrees of disequilibrium. As demonstrated in a previous white paper, the extreme bounds of this disequilibrium are 1) 100% equilibrium and 2) triple separated disequilibrium.

The mobile counter was calibrated with a phantom containing approximately 30 mg of Th-232 with daughters in disequilibrium. The degree of disequilibrium falls between the two extremes mentioned above (Th-232 to Pb-212 activity ratio = 1.67).

Assume it is known that an individual has 30 mg of Th-232 in his lungs. This is the *actual content* of the lungs, not the value reported by the mobile counter. From the two extremes of disequilibrium, we can calculate the amount of Pb-212 in the lungs as falling between 3.3 nCi (100% equilibrium) and 0.63 nCi (triple separation).

Ideally, if the disequilibrium of both the phantom and the inhaled material are known, the real Pb-212 activity would be calculated from the reported thorium value and the real thorium value would then be back calculated from this real Pb-212 activity. Without knowing the degree of disequilibrium this cannot be done but a bounding value can be determined, which is what is required for this program.

To determine the bounding value, the Pb-212 activity is calculated using one extreme of the disequilibrium and then the thorium is back calculated using the opposite extreme disequilibrium. The disequilibrium can be chosen for each step such that the upper and lower bounds are determined.

In the example case above, the *reported* value in the lungs could be higher or lower than the actual 30 mg, depending on the degree of disequilibrium of the inhaled material. Since the calibration phantom falls between the two disequilibrium ratios, the upper bound Pb-212 activity can be determined by assuming 100% equilibrium when calculating the Pb-212 activity from the reported thorium value. The upper bound thorium value can then be back-calculated from this Pb activity by assuming the triple separation disequilibrium.

For example, for a reported thorium value of 20 mg, the Pb-212 activity would be calculated to be 2.2 nCi assuming 100% equilibrium. The bounding thorium value would then be back-calculated to be 105 mg, based on triple-separated material.

It should be noted that for the actual procedure an individual's intake will be calculated using the Pb-212 values because, within a month or so after separation, it is in equilibrium with the Th-228. Thus, given a Th-232/Th-228 ratio for the inhaled material we can model the intakes of all members of the Th-232 decay chain. The intake will be calculated assuming the triple separation disequilibrium. This results in essentially the same process as above but this step was left out for clarity.