

IONIZING RADIATION

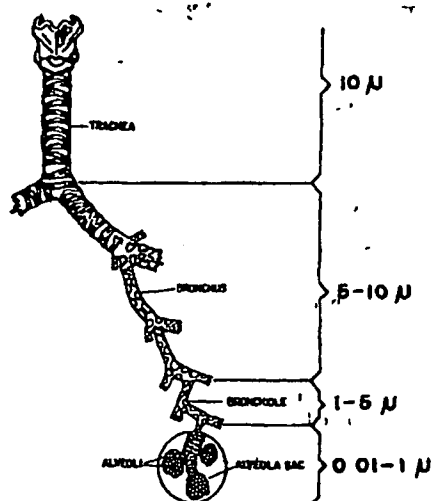


Fig. 42-10. Deposition of materials inhaled into the bronchial tree, according to particle size in microns.

Adapted from "Atomic Radiation,"
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000 μ = 1 meter) in size are of health significance, because they do not settle out even over long periods of time and are sufficiently small that they are not removed in the nasal passages as are the larger particles. Particles smaller than 5 to 10 μ , then, can penetrate deep into the lung (Fig 42-10).

The volume of a 10 μ (10^{-4} centimeters) sphere is 0.524×10^{-9} cubic centimeters (cu cm). For plutonium (sp gr 19.74) the weight of the 10- μ diameter particle is 1.04×10^{-8} gm.

The amount of activity in a particle 10 μ in diameter can be calculated. The curies per gram (a constant) is known as the "specific activity" of a radionuclide and may be obtained from tables (for example in *Radio-logical Health*) or calculated from the expression:

$$\text{Curies/gram} = \frac{1.308 \times 10^9}{(\text{atomic weight}) (\text{half-life in days})}$$

For plutonium, with a half-life of 88×10^6 days and the atomic weight 239, the

formula yields a specific activity of 0.062 curie per gram.

The 10- μ plutonium particle weighs 1.04×10^{-8} gm with 6.4×10^{-10} curie in the particle. The number of these particles which may be breathed in a day at the permissible level can now be calculated.

A man at work is considered to breathe 10 cu m (10^7 cu cm) per eight-hour shift. Then, 1 particle per day = $\frac{6.4 \times 10^{-10}}{10^7} =$

6.4×10^{-17} curie per cu cm or 6.4×10^{-10} microcurie (μ c) per cu cm. Since the guide level is 2×10^{-10} (μ c) per cu cm (from NBS Handbook 69, p. 87 under ^{239}Pu "Bone"), it is found that one such particle per shift is 32 times too much.

Plutonium is one of the more hazardous radioisotopes that can be inhaled. Since the volume varies as the cube of the diameter, a particle 10 μ in diameter has the same weight as 1,000 particles 1 μ in diameter or the same weight as 1,000,000 particles 0.1 μ in diameter. Therefore, the guide daily level would be 0.0314 of 1 particle 10 μ in diameter, 31.4 particles 1 μ in diameter, or 31,400 particles 1/10 μ in diameter. As shown in Table 43-C, similar calculations can be made for other radioisotopes.

Particles in the range of sizes shown in Table 43-C are commonly found around industrial operations. Since the particle size greatly affects the risk of operations with radioactive materials, the volume of air taken in a sample must be large enough not only to ensure collection of particulates in the distribution of sizes probably present but also to yield an amount of activity above the minimum detectable quantity of the analytical method. The sampled air volume should be large enough to place the concentration below the limit of the radioactivity concentration guide (RCG) for the minimum detectable quantity. Therefore a knowledge of the actual particle size distribution is important.

For instance, it is necessary to sample 10 cu m of air during the time that the work operation is being conducted to trap 31.4 one- μ particles of plutonium. Thirty-one is a reasonable number of 1- μ particles to collect to give confidence to the measurements, but for 1 ten- μ particle, 320 cu m of air are needed to yield a guide level concentration.