The Importance and Quantification of Plutonium Binding in Human Lungs

Alan Birchall[1,4], Matthew Puncher[2,4], Alan Hodgson[2], Sergei Y. Tolmachev[3]

[1]Global Dosimetry Ltd., UK; [2]Public Health England (PHE), UK; [3]U.S. Transuranium and Uranium Registries, Washington State University, USA; [4]Posthumous

Epidemiological studies have shown that the main risk arising from exposure to plutonium aerosols is lung cancer, with other detrimental effects in the bone and liver. A realistic assessment of these risks, in turn, depends on the accuracy of the dosimetric models used to calculate doses in such studies. A state-of-the-art biokinetic model for plutonium, based on the current International Commission on Radiological Protection biokinetic model, has been developed for this purpose in an epidemiological study involving the plutonium exposure of Mayak workers in Ozersk, Russia. One important consequence of this model is that the lung dose is extremely sensitive to the fraction (f_b) of plutonium, which becomes bound to lung tissue after it dissolves. It has been shown that if just 1% of the material becomes bound in the bronchial region, this will double the lung dose. Furthermore, f_b is very difficult to quantify from experimental measurements. This paper summarizes the work carried out thus far to quantify f_b. Bayesian techniques have been used to analyze data from different sources, including both humans and dogs, and the results suggest a small, but nonzero, fraction of < 1%. A Bayesian analysis of 20 Mayak workers exposed to plutonium nitrate suggests an f_b between 0 and 0.3%. Based on this work, the International Commission on Radiological Protection is currently considering the adoption of a value of 0.2% for the default bound fraction for all actinides in its forthcoming recommendations on internal dosimetry. In an attempt to corroborate these findings, further experimental work has been carried out by the United States Transuranium and Uranium Registries. This work has involved direct measurements of plutonium in the respiratory tract tissues of workers who have been exposed to soluble plutonium nitrate. Without binding, one would not expect to see any activity remaining in the lungs at long times after exposure since it would have been cleared by the natural process of mucociliary clearance. Further supportive study of workers exposed to plutonium oxide is planned. This paper ascertains the extent to which these results corroborate previous inferences concerning the bound fraction.

USTUR-0436A-16