EXHIBIT O

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Answer to Question #4817 Submitted to "Ask the Experts"

Category: Radiation Basics — Photons

The following question was answered by an expert in the appropriate field:

Q

What value should be taken as the average gamma energy of ^{226}Ra?

A

Most of the significant gamma radiation from ^{226}Ra decay comes from the radioactive progeny ^{214}Pb and its daughter, ^{214}Bi. These are produced following the decay of ^{226}Ra to ^{222}Rn, which then decays to ^{214}Pb. Since ^{222}Rn is a gas it will escape, to varying degrees, from unsealed sources, and the gamma radiation from the ^{214}Pb and ^{214}Bi may not be significant in such cases. In sealed sources that prevent leakage of ^{222}Rn, the ^{222}Rn, ^{214}Pb, and ^{214}Bi each reach the same activity level as that of the ^{226}Ra within a few weeks of preparation of the source. There are dozens of different gamma rays of varying energies and yields produced by the decay of ^{226}Ra and its progeny; energies range from less than 50 keV to about 2.5 MeV. The energies and numbers of gamma rays that escape from the source depend on how the source is fabricated, in particular the type of material used for the source encapsulation and its thickness. Generally, for most practical sealed sources of ^{226}Ra, photons with energies less than about 50 keV are not very important from a dose perspective. If we neglect photons lower in energy than 50 keV and also consider only photons with yields greater than 1%, we obtain an effective gamma energy of about 0.74 MeV (obtained by multiplying each photon energy by its respective fractional yield, summing up all such products, and dividing the result by the sum of all the photon yields). Herman Cember's text (*Introduction to Health Physics*, 3rd ed., McGraw Hill, 1996) gives the average energy as about 0.7 MeV, and Report 112 of the National Council on Radiation Protection and Measurements (Calibration of Survey Instruments Used in Radiation Protection for the Assessment of Ionizing Radiation Fields and Radioactive Surface Contamination, 1991) gives an effective gamma energy of 800 keV (p. 54).

Depending on the purpose for which the gamma radiation is being used, you may require better definition of the energy distribution from the source, in which instance you may have to make corrections for attenuation of photons of differing energies within the source materials or possibly make measurements of the gamma ray distribution being emitted from the source. The latter process requires use of a gamma spectrometric system and setup of the source to produce an acceptable photon fluence at the detector used, which would probably be a germanium detector in conjunction with a multichannel gamma analyzer. I hope this answer is sufficient for your needs.

George Chabot, PhD, CHP

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