Practice 3 of FYSKJM4710 Spring 2006

Measurements of neutron doses by thermo-luminescence dosimetry

The task takes place at the new radiation therapy department of the Radium hospital.

Equipment: 1 Neutron scours (^{239}Pu/^{9}Be), 1 ^{60}Co γ-source, Thermo luminescence (TL) dosimeters, 1 Harshaw 5500 automatic TL-readout

Most of the task is a demonstration, but the result is to be analyzed and presented by each one!

The neutron scours is a mixture of and ^{9}Be. Neutrons are created by the following reaction:

^{239}Pu$\rightarrow \alpha$ + fission products

^{9}Be + $\alpha \rightarrow {}^{13}C^{*} \rightarrow {}^{14}$C + n

Maximal neutron energy is about 11 MeV, but the mean energy is 4 MeV. Some γ-radiation follows the neutrons. The TL-dosimeters are mounted on a rod at different distances from the surface of the neutron scours, (0.5, 2, 4, 8, and 16 cm, 3 dosimeters at each distance). The dosimeters were exposed for about 288 Hours (12 days) and the dose is unknown.

By using the ^{60}Co γ-scours a calibration curve of the TL-dosimeters have been found by radiating the dosimeters with known doses of 250,500 and 750 mGy. Its formula when x=TL-intensity and y=dose in mGy is given by: y = 2.9315x-1.5231

a) Give a short description of the TL-dosimetry method.

b) What is a preheating procedure and why can it be favorable?

c) Place all of the dosimeters in the numbered disk that are to be placed in the TL-reader. Keep track of each dosimeter! Read out the TL-intensity of each dosimeter and save the result to a diskette.

d) Use the calibration formula to calculate the doses to each of the neutron radiated dosimeters. Find the standard deviation of each of the 5 positions. Plot the average dose of each position (with standard deviation bars) as a function of distance from the surface of the neutron scours.

e) Plot the inverse of the average dose as a function of the distance. If using Excel you can add a polynomial trend line of second order (1/dose=y=ax^2+bx+c). What is the dose rate at the surface (x=0cm) and the dose rate at 1 meter from the scours? How long most you hold the scours (0cm) and how long can you stay at a distance of 1 meter to get the same skin dose of 1mGy?

f) Below are the neutron spectrum of the scours given (number of neutrons per energy interval) It is seen that the neutrons interacting with the dosimeters can have energies from 0 to about 11 MeV (The low energetic part below 2 MeV is highly uncertain)

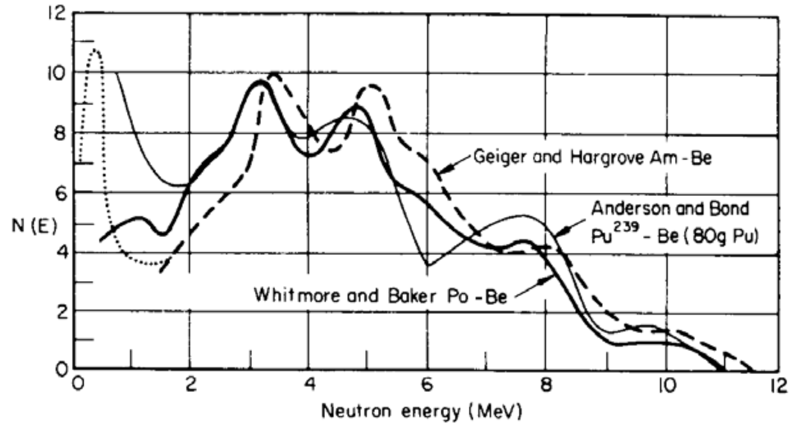

FIGURE 16.3. Neutron spectra for three Be(α, n) sources: ^{241}Am, ^{210}Po, and ^{239}Pu. (From DePangher and Tochilin, 1969. Sources of the data are given in that reference. Reproduced with permission from E. Tochilin and Academic Press.)

If the dose to water is to be calculated (to give a better estimation of dose to humans than the elements in the TL-dosimeters) can the following relation be used:

$$\frac{D_{vann}}{D_{TL-dosimeter}} \approx \frac{(F_n)_{vann}}{(F_n)_{TL-dosimeter}}$$

where F_n is the *kerma-factor* dependent of the neutron energy and absorbent. (The kerma-factor corresponds to the energy-absorption-coefficient (μ_{en}/ρ) of photons). F_n of water and TL-dosimeters (made of lithium fluoride; LiF) is given below.

What happens to the dose relation between water and TL-dosimeters if the neutron spectrum has a large fraction of low energetic neutrons? And if there only are neutrons with energies above 0.1 MeV?

Why is it important to have god descriptions of the neutron spectrum (even better than that seen in the graph above) if doses measured with TL-dosimeters are to be converted to dose to water (humans)?