Measurement of neutron kerma factors at 18, 23, and 25 MeV

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Neutron damage is caused by the absorption of neutron energy in matter. This process is initiated by neutrons transferring their energy to charged particles. Kerma, which is defined as the expectation value of the initial kinetic energy transferred from neutrons to charged particles per unit mass of material, quantifies the initial step in the energy deposition process. The kerma factor is defined as the kerma per unit neutron fluence.

This dissertation reports neutron kerma factors in C, O, Mg, Si, and Fe at 18, 23, and 25 MeV neutron energy, determined by measuring the energy absorbed by the ionization gas of proportional counters constructed of C, ZrO_2, Zr, Mg, Si, and Fe walls, exposed to a well characterized neutron field. Spherical and cylindrical proportional counters measured neutron kerma, while detection of the activity induced in teflon samples, $(C_2F_4)_n$, by the $^{19}F(n,2n)^{18}F$ reaction determined the fast neutron fluence. The oxygen kerma factor was determined by simultaneously irradiating Zr and ZrO_2 proportional counters and subtracting the kerma measured in Zr from the ZrO_2 kerma. Deuteron bombardment of a tritium gas target provided our neutron source, which consisted of monoenergetic fast neutrons accompanied by a contaminating flux of lower energy neutrons. These secondary neutrons contributed significantly to the measured neutron kerma, but did not affect activation measurements. At each deuteron bombardment energy, we determined the neutron spectrum by time-of-flight spectrometry. The lower-energy neutron spectrum, convolved with tabulated energy-dependent kerma factors, provided the secondary neutron kerma needed to correct total kerma measurements.

Neutron kerma factors provide the basic physical data necessary to convert neutron fluence to radiation dose in matter. The results described are the only direct measurements of the oxygen, magnesium, and silicon kerma factors above 20 MeV neutron energy, and the only measurements of the iron kerma factor above 15 MeV. They provide data of immediate relevance to neutron radiotherapy and impose additional criteria for normalizing and testing nuclear models used to calculate kerma factors at higher neutron energies.