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January 20, 1953

To: P. E. Collins

From: J. S. Reddie and W. C. Roesch

SOURCE STRENGTH AND SHIELDING ESTIMATES

SUMMARY

A 2000 gram sample of plutonium fluoride will give a fast neutron dose rate of about 100 mrem/hr at one foot and a gamma ray dose rate of about 25 mr/hr at one foot. Estimates of the shielding required to reduce these dose rates to safe levels are given below.

SOURCE STRENGTHS

We have taken two sets of data from which it is possible to estimate the fast neutron source strengths. In 1949 neutron fluxes at several distances from two jars, each containing 320 grams of plutonium fluoride, were measured with a recoil proton counter. Using the relationship[1] 0.074 mrem/hr per neutron/cm^2/sec, these measurements indicated 110 mrem/hr at one foot from 2000 grams of the fluoride. Another set of measurements was taken recently with a moderated BF_3 counter which had been given an accurate, free-air calibration. These measurements indicated 56 mrem/hr at one foot from 2000 grams of the fluoride.

We believe that the recoil proton counter gave results too high because of variation in energy sensitivity between the calibration source of radium beryllium neutrons and the observed plutonium fluoride neutrons. We believe the moderated BF_3 counter gave results too low because of geometrical effects. All things considered, we believe 100 mrem/hr is a good estimate for the fast neutron dose rate at one foot from 2000 grams of plutonium fluoride.

The gamma rays from 350 grams of the fluoride were measured with a CP meter. The result, without any correction for energy sensitivity of the CP, indicated 16 mr/hr at one foot from 2000 grams of the fluoride. Previous measurements(2) indicate that about three fourths of this dose rate is due to 17 Kev X-rays for which the CP requires(3) a correction factor of 1.7. This leads to the result--25 mr/hr at one foot from 2000 grams of plutonium fluoride.

SHIELDING

The shielding properties of water for these fast neutrons can be estimated from the data of F. R. Jones(4). The dose rate at r feet from the source behind x cm of water when the dose rate is Do at one foot can be written

$$D = Do \frac{B e^{-ux}}{r^2}$$

For water B = 2 and u = 0.12 cm^{-1}. For the gamma rays B = 1 and u = 0.06 cm^{-1}.

The necessary shield thickness at any distance can be calculated using this formula and adding the dose rates due to the neutrons and gamma rays. For example, at four feet from the source 7 cm of water will reduce the dose rate to 6¼ mrem/hr and 25 cm will reduce it to 1 mrem/hr.

Another consideration in designing shielding for such a source is the radiation already present from other sources. Our experience indicates that these other radiations will be of a magnitude comparable to those discussed here.

Radiation Measurements Unit
RADIOLOGICAL SCIENCES DEPARTMENT

(1) "Radiation Studies 234-5 Building (III) Nuclear Track Film," W. C. Roesch, HW-22020, SECRET

(2) "Radiation Studies 234-5 Building (I)," W. C. Roesch, J. S. Reddie, and E. C. Watson, HW-20785, SECRET

(3) "Radiation Studies 234-5 Building (II)," W. C. Roesch and E. C. Watson, HW-21378, SECRET

(4) "Shields for Neutron Sources," F. R. Jones, HW-21169, UNCLASSIFIED