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TO THE
USAEC DIVISION OF BIOMEDICAL AND ENVIRONMENTAL RESEARCH
PART 4 PHYSICAL AND ANALYTICAL SCIENCES

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On January 19, 1975, research and development programs of the U.S. Atomic Energy Commission (AEC) became part of the newly formed Energy Research and Development Administration (ERDA). In this report, since it refers to work done in 1974, most references are to AEC programs.

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• RECIPIENT RADIATION EXPOSURE

The objective of this study is to determine the dose from radioisotopic heat sources suitable for circulatory support systems. Computations and measurements were undertaken to form a basis for population dose calculations. The data are presented in terms of average dose rates to a bystander as a function of distance from a recipient.

Circulatory Support Systems F. T. Cross

For the dose rate calculations, two heterogeneous mathematical phantoms as described in MIRD Pamphlet No. 5, *J. Nucl. Med.*, 10, Supplement 3, 1969 (see also Figure 5.3) were used to represent the artificial heart recipient (Phantom 1) and the bystander (Phantom 2). A Rando® female trunk phantom was used to measure the bystander dose rates and is shown in Figure 5.4. Thermoluminescent dosimeters were placed on the surfaces of this phantom, along the centerline and various other internal locations in order to determine average photon dose rates as a function of source-phantom separations. The neutron dose rates were measured with a small tissue-equivalent proportional counter which was incorporated into the Rando phantom by use of a specially constructed slab drilled to insert the dosimeter from the posterior side. The recipient phantom was built-up from tissue-equivalent material of varying frontal thickness to determine the effect of depth of burial of the artificial heart power source.

A ^{252}Cf source was used as a standard for plutonium in order to increase the range of neutron dose measurements and to decrease the experimental time. The californium neutron dose rates were normalized to plutonium on the basis of relative neutron emission rates cross-checked by a few relative dose rate measurements. A

nominal 50 W electrorefined $^{238}\text{PuO}_2$ source (80.14 wt% ^{238}Pu and 0.64 ppm ^{236}Pu impurity) was used to represent the artificial heart power source. The measurements were corrected to beginning of life or 0 years post-electrorefining. The measurements were further corrected for experimental variabilities in order to compare to the computations which were for a nominal 33 W source containing 0.3 ppm ^{236}Pu and located on the recipient centerline at 22 cm above the plane separating the trunk from the legs. This size source is more representative of that projected for powering the artificial heart.

Figure 5.5 shows the computations normalized to the measurements for a 33 W ^{238}Pu source containing 0.3 ppm ^{236}Pu . The dose rates, with an estimated accuracy of $\pm 25\%$, are shown at beginning of life or 0 years post-electrorefining. The integrated dose rates in gm-mrem/hr can be determined by multiplying the values in Figure 5.5 by the masses of the various regions which are given in the MIRD Pamphlet as 43,982 gms for the trunk, 70,036 gms for the total body, 5,278 gms for the head and 20,776 gms for the legs. As the mean design life of the artificial heart is projected at 10 years, the photon dose rates in Figure 5.5 should be multiplied by 1.9 to account for the ^{236}Pu impurity at 10 years and by 1.4 to determine the mean photon dose rates over the 10-year period (for extrapolation purposes, the mean photon dose rates

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FIGURE 5.3. Dimensions and Coordinate System of Adult Human Phantom.

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FIGURE 5.5. Average Dose Rates to Phantom 2.

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FIGURE 5.4. Average Woman Rando Trunk Phantom.

would increase by a factor of 2.0 for 0.6 ppm ^{236}Pu impurity). The mean neutron dose rates are about 4% lower than the values in Figure 5.5 for the 10-year period.

As demonstrated in Figure 5.5, the regional neutron and photon dose rates converge upon one another as the phantom separations increase. With even as close as a 4 ft separation, the values are within 20%. For source locations other than (0,0,22) the dose rates to Phantom 2 can be adjusted by application of the usual inverse-square of the distance and the exponential change in dose rate with tissue thickness. The tissue interaction coefficient is approximately 0.031 cm^{-1} for the photons and 0.121 cm^{-1} for the neutrons.