PROGRESS REPORT NO. 13

NASA ORDER NO. R-75

ENERGY DISSIPATION CHARACTERISTICS IN TISSUE FOR IONIZING RADIATION IN SPACE

Submitted to NASA, Washington, D. C.

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GPO PRICE $ ________

CFSTI PRICE(S) $ ________

Hard copy (HC) $1.00

Microfiche (MF) .50

ff 653 July 65

N66 24123

N66 24123 (ACCESSION NUMBER)	(THRU)
3 (PAGES)	1 (CODE)
CR-71812 (NASA CR OR TMX OR AD NUMBER)	04 (CATEGORY)

FACILITY FORM 602

Period Covered

1 Dec 1965 - 28 Feb 1966

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U. S. NAVAL AVIATION MEDICAL CENTER
PENSACOLA, FLORIDA

In the November 1965 session of the Space Radiation Study Panel of the Research Council the fact was discussed that for most solar particle beams under of light shielding (LEM, EVA) the radiation dose in the skin will be substantially than in deeper regions of the body and will be the limiting factor as far as permissible exposure is concerned. Concern was also expressed with regard to the RBE factors of alpha and medium heavy component of flare beams. A formal request was directed to investigator for a more comprehensive analysis of the pertinent dose distributions both on the rad and rem dose level. The earlier study of the same basic problem (see Progress Report No. 10) was considered insufficient inasmuch as only one representative flare event had been evaluated. Since the alpha and medium heavy flux in flare beams greatly in relation to the proton flux, a more comprehensive study identifying the upper and lower limit for the fluxes in question and establishing the corresponding dose distributions in near-surface regions of the body seemed indeed a very desirable supplement the earlier analysis.

In compliance with the just-indicated request, the computer code of the earlier study was utilized for the evaluation of additional flare spectra. Three representative spectra were selected with rigidity gradients corresponding to P_o values of 50, 125, and 300 Mv in the exponential formula $J = J_o \exp(-P/P_o)$ for the integral spectrum. The low value of 50 Mv closely corresponds to the steepest spectrum ever recorded, the one for the July 13, 1961 flare, whereas 300 Mv corresponds to the hardest spectrum, the one of November 15, 1960.

The study is essentially completed and the graphical presentation of the results for publication is in progress. The data show that the contributions of the alpha and medium heavy component to total dose grow substantially as P_o grows, i.e., as the spectrum hardens. The rad doses in the skin, for a normalized proton dose rate of 100 rads/hr, are listed in Table I. The doses hold for a proton/alpha flux ratio in the rigidity spectrum of 1:1 and an alpha/medium heavy ratio of 60:1. These two ratios are the maximum values observed in flare beams. The dose ratios in Table I, therefore likewise represent maximum values for the contributions of the alpha and medium heavy component, which would be encountered only in flares with the high flux ratios quoted above.

The dose fractions from the heavy components shown in Table I are further substantially magnified if rad doses are converted to rem doses. If the RBE/LET relationship recommended by the RBE Committee of the ICRP is applied, an RBE factor of 4.0 for the alpha dose shown in Table I is obtained. This factor drops at first sharply and then more gradually in going from the skin to deeper regions of the body. The net result of this RBE transition is a substantial additional steepening of the depth dose distribution which further widens the difference in the exposure of the skin and the deeper regions.

Problematic is the conversion of rad to rem doses for the medium heavy component inasmuch as official recommendations do not contain provisions for the

Table I

Skin Doses Behind 0.1 g/cm² Shielding in Solar Particle Beams with Different Spectral Rigidity Gradients

P_o, Mv	Skin Dose, rads/hr Protons	Alpha	Med. Heavy
50	100	33	.77
125	100	188	11
300	100	407	34

Spectra are assumed to obey exponential rigidity law $J = J_o \exp(-P/P_o)$ for all 3 nuclear species (protons, alpha particles, and medium heavy nuclei) with flux ratios 60:60:1. J_o is normalized for equal skin doses from protons in all 3 spectra.

very high LET values of these nuclei. Tentatively, an RBE/LET function saturating at 10 has been assumed in the evaluation. It is interesting to note that, contrary to the alpha component which shows a rapid drop of the local RBE in the first few millimeters of tissue, the medium heavy component maintains an RBE above 8 down to almost 1 centimeter of depth in tissue.

A research report presenting the data in detail should be available in about 6 weeks. Work on the study of the galactic radiation at solar minimum with special emphasis on exposures on long-term missions as outlined in Progress Report No. 12 has already been resumed.