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ESTIMATE OF BETA REP DOSE TO SKIN OF JAPANESE FISHERMEN.

One particle of fallout from the Japanese fishing ship was found to have an activity of 3.1×10^8 d/m/gm on April 7th. Based on the attached calculations, the dose rate at the time of fallout was about 4,600 reps/hr. One does not know the length of time such fallout stayed in place but the following table suggests the total beta rep dose for varying lengths of placement based on an initial dose rate of 4600 reps/hr. (Any contribution from Neptunium is ignored.)

Duration of Placement of Fallout Material	Approximate Rep Dose At A Depth of 7 mg/cm^2
1 hr.	4,150
2 hrs.	8,000
3 hrs.	11,200
4 hrs.	14,600
8 hrs.	23,800
24 hrs.	44,000
48 hrs.	60,000

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In relating these doses to past experiences, attention may be drawn to three sources of information. In experimentally induced beta burns on sheep at LASL it was found that 2500 reps produced superficial ulceration in 13 days.(a) 25,000 reps produced ulcerations extending throughout the thickness of the epidermis.

One of the best sets of experimental data is that of Moritz and Henriques using pigs(b). The following information is taken from their work:

(a) "Comparative Study of Experimentally Produced Beta Lesions and Skin Lesions in Utah Range Sheep" by Lushbaugh, C. E., Spalding, J. F., and Hale, D. B., November 30, 1953, Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

(b) "Effect of Beta Rays on the Skin as a Function of the Energy, Intensity and Duration of Radiation II. Animal Experiments" by Moritz, A. R., M.D., and Henriques, F. W., Jr., Ph.D., Reprinted from Vol. 1, No. 2, Summer, 1952, Laboratory Investigation.

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"The threshold surface dose required to produce recognizable injury in the pigskin varied from 20,000-30,000 reps for sulphur^{35} (0.17 Mev) to 1,500-2,000 reps for Yttrium^{91} (1.53 Mev), and Strontium^{90} (0.61 Mev)-Yttrium^{90} (2.20 Mev) in equilibrium. The epidermal damage is directly related to the dose that reaches the active layers of cells which comprise the deepest portion of the epidermis. (In a living porcine skin this is about 0.09 millimeters while in human skin it is assumed to be 0.07 millimeters). For the five sets of isotopes used (S^{35}, Co^{60}, Ce^{137}, Y^{91}, Sr^{90}-Y^{90}), the apparently wide variance in surface rep dose actually resulted in a comparatively constant dose at a depth of 0.09 mm equal to 1400 ± 300 reps and produced equivalent epidermal injury.

"With a 1500-2000 surface rep dose of Sr^{90}-Y^{90} the epidermal injury was recognizable only by microscopic examination one to two weeks after exposure and rarely persisted for more than two or three weeks. The action was reversible with no residual abnormalities.

"With not too much larger rep doses (2000-2500), early erythema was followed by epidermal exfoliation (peeling and shedding of the horny layer of the skin) and epilation. Permanent destruction of the hair follicles and subacious glands occurred.

"Surface doses more than twice those required to produce exfoliation (about 5,000 rep for Sr^{90}-Y^{90}) often caused epidermal necrosis with ulceration of the entire target area. Sometimes the development of the horny crust masked the ulceration. The time of appearance of ulceration varied widely from 48 hours, during which marked changes took place resulting in deep punched-out ulcers over the entire area, to several weeks before the epidermal necrosis was complete which were often masked by the attached crust of exfoliated cells."

The third set of data is by Knowlton et al.(c) on beta burns suffered at Eniwetok. Four men were hospitalized with severe beta burns following the handling of radioactive material. It was estimated that they received 3,000 - 16000 reps to the outer surface of the skin.

(c) "Beta Ray Burns of Human Skin", by Knowlton, Norman P., Jr., et al., The Journal of the American Medical Association, Vol. 141, No. 4, September 24, 1949.

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These data suggest that the estimated rep dose to the skin of the Japanese fishermen was more than adequate to produce the lesions observed. It is to be repeated, however, that these calculations are based on the very limited data gleaned from the specific activity of a single fallout particle.

Attachment: Annex

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ANNEX

CALCULATION OF BETA DOSE TO SKIN OF JAPANESE FISHERMEN

1. 3.1×10^8 d/m/gm on April 7 extrapolated to the 8th hour after detonation (assumed time of fallout) by the 1.2 law, becomes 9.2×10^{10} d/m/gm.

2. Assume 1 gm of the fallout material with a density of 2.5 is spread out over 100 cm^2. This produces a thickness of 0.01 gm/cm^2, or 40 microns.

3. Referring to Fig. 4 of "Distributed Beta Sources in Uniformly Absorbing Media" and assuming $\mu = .25$ cm^2/gm*,

$$\underline{\mu x} = (0.01)(25) = 0.25$$

$$\underline{\mu x} = (0.007)(25) = 0.175$$

(This assumes a density of 2.5 for the fallout material.)

Entering the graph with these parameters, the point found is 0.12; i.e., 0.12 of the equilibrium dose rate will be delivered at a depth of tissue equivalent to 7 mg/cm^2.

4. The equilibrium dose rate is

$$(9.2 \times 10^{10})(0.4) = 3.7 \times 10^{10} \text{ Mev/gm-min}$$

The dose rate at a tissue depth of 7 mg/cm^2 is

$$(3.7 \times 10^{10})(0.12) = 4.4 \times 10^{9} \text{ Mev/gm-min}$$

$$(4.4 \times 10^{9})(1.6 \times 10^{-6})(1/93) = 76.5 \text{ reps/min}$$

$$\cong 4,600 \text{ reps/hr at 8th hour.}$$

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*"Distributed Beta Sources in Uniformly Absorbing Media", by Rossi, H. H., and Ellis, N. N., Jr., Reprinted from Nucleonics, July 1950, Vol. 7, No. 1, Pages 18-25, and August 1950, Vol. 7, No. 2, Pages 19-25.
(It is recognized that we are not dealing with uniformly absorbing media here, but the error introduced will not invalidate the conclusion.)
WT-18. "Operation GREENHOUSE. Scientific Director's Report, Annex 2.2. Control Studies Performed in the United States and at Eniwetok. Parts I, II, IV, and VI. Nuclear Explosions, 1951"

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