Radon

THE UNIVERSITY OF ROCHESTER
SCHOOL OF MEDICINE AND DENTISTRY
POST OFFICE BOX 287, STATION 3
ROCHESTER 20, NEW YORK

723956

ATOMIC ENERGY PROJECT
(ADMINISTERED BY THE DEPARTMENT OF RADIATION BIOLOGY UNDER CONTRACT WITH THE U. S. ATOMIC ENERGY COMMISSION)

AUG 23 1954

August 18, 1954

Dr. Karl Z. Morgan, Director
Health Physics Division
Oak Ridge National Laboratory
Post Office Box P
Oak Ridge, Tennessee

Dear Dr. Morgan:

In reply to your letter of July 30, the average value of alpha particle energy of 7.58 Mev given on page 141 of UR-298 was obtained as follows:

From page 24 of the report, the relative activities of RaA and RaC' which build up in a system which filters the daughter products from the air for several hours are 5.53 and 89.9 respectively. The energies of the RaA and RaC' alphas are given in Table 3, page 17 of the report as 6 Mev. and 7.68 Mev respectively.

The average energy is then calculated as

$$\frac{(6)(5.53) + (7.68)(89.9)}{89.9 + 5.53} = 7.58 \text{ Mev}$$

I believe that the permissible limit of exposure to radon should be based on exposure to the bronchial passageways rather than on average exposure to the entire mass of lung tissue. As you indicate, calculations based on bronchial exposure give lower MPC values than those considering the exposure to the whole lung, and our measurements bear this out. We're trying now to get an idea as to what part of the respiratory tree does get the maximum dosage and the extent of the dosage. I believe we'll be able to furnish you with some data in the near future.

Of course, the calculation of dosage from measurements of the radioactivity of respiratory passageways still depends on the assumption of a value for the volume of tissue irradiated. I have been using as this volume a cylindrical shell whose inner radius is the inner radius of the respiratory tube and whose thickness is the range of the alpha particles in water. I should be interested in knowing if you use any other method for the calculation of the volume of tissue irradiated.

Sincerely,

Jack Shapiro
Jacob Shapiro

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A-00556
Human Studies Project

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$$\frac{Q_a A}{Q_a B} = \frac{13.68 \times 3.05}{7.68 \times 28.6}$$

41.7

219.6

.184

.102

$\lambda_1 Q_1 = \lambda_2 Q_2 = \ldots$

$Q_2 = \ldots$

$\left(\frac{a^4}{sec}\right) \left(\frac{sec}{min}\right)$

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July 30, 1954

Dr. Jacob Shapiro
The University of Rochester
School of Medicine and Dentistry
P. O. Box 287, Station 3
Rochester 20, New York

Dear Dr. Shapiro:

Thank you very much for your letter of July 13, and the information which it contained.

I gather from your report that a person retains about 25% of the inhaled daughter products from an uncleaned atmosphere or 75% in a cleaned atmosphere. If the radon gas is introduced into these atmospheres and permitted to reach equilibrium with its products, I presume, from what you say in your letter, that the higher retention is due to the smaller particles and an increase in the Brownian movement. This would probably indicate a retention lower in the respiratory tract also. It is interesting to note that these percents are in the opposite direction from what we encounter in practice because the daughter products are removed to start with from the cleaned air at a rate depending upon the air turnover in the building.

I am enclosing a copy of a paper I prepared three years ago, which supports the argument of Bale, and I believe adds energy from an additional daughter product. I do not have a copy of this paper before me at the moment, so cannot check this point. In any case, the addition of this product further strengthens his argument. You will note that the permissible concentration based on 0.3 rem per week to the bronchial passages is much lower than obtained from your method of calculation on page 141, and I will not be happy until the search is accomplished which will indicate whether the permissible limit should be set on the basis of a limited portion of respiratory tract or upon the entire mass. In this enclosed paper I have made a few corrections which take into account recent changes in definitions. There is one question I still have relative to page 141, namely, how did you get the average value of alpha particle energy of 7.58 Mev? Also you will note in next to the last line there is a typographical error where you have 1.68×10^{-5}, and it should be 1.68×10^{5}.

In light of your excellent report I will be most pleased if you have any specific recommendations as to what should be the maximum

permissible concentration of radon in air when it is maintained with an equilibrium quantity of daughter products. In most situations this would be in dusty air, and I presume you would apply your 25% retention. Perhaps this value would drop even lower in extremely dusty air, or might even increase if the average particle size were much in excess of one micron. In any case I would be happy to receive any specific recommendations from you and Bill Bale that will aid us either in justifying the new value of 10^{-7} μc/cc or furnish ammunition for returning to the former value, or even lower value for our international report.

Sincerely,

Karl Z. Morgan, Director
Health Physics Division

KZM/bmh

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JUL 23 1954

ATOMIC ENERGY PROJECT
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July 13, 1954

Dr. Karl Z. Morgan, Director
Health Physics Division
Oak Ridge National Laboratory
Post Office Box P
Oak Ridge, Tenn.

Dear Dr. Morgan:

The attached sheet gives the calculation of the average dose rates to the lung from (1) deposition of the radon daughter products, and from (2) radon and the daughter products of the radon molecules decaying in the lungs. The results of the calculation are summarized on page 121, paragraph 2, of the University of Rochester Atomic Energy Project Report UR-298, "An Evaluation of the Pulmonary Radiation Dosage from Radon and Its Daughter Products."

The calculation was made assuming a retention of 25 per cent, a minute volume of ten liters, and a lung weight of one kilogram. The minute volume was the average minute volume measured for the subject during the retention experiment (Table 26, p. 94, of UR-298). The retention depends on the breathing pattern, and the 25 per cent retention figure can be used to calculate dose rate only for the breathing pattern with which it was obtained.

An idea of the variation of dose among individuals of a species may be obtained from Table 19, p. 79, which summarizes the rat dosages. The average dosage to 15 rats was 334, the standard deviation was 118. Some dog data are given on page 89.

The deposition of the daughter products is probably mainly by diffusion to the walls of the air passageways by Brownian movement. Accordingly, I believe that average lung dosages among individuals with different breathing patterns will be smoothed out somewhat because per cent deposition will likely change in a direction opposite to the change of the minute volume. We shall need more data before we can make any definite conclusions on this point. However, from Table 25, p. 89, it also seems that tracheal dosage depends very strongly on the breathing pattern and

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dosage to the large bronchial tubes may be the critical dosages in radon exposure.

I am sorry that I overlooked mentioning in the calculation of the dosage from radon in equilibrium with its daughter products that the lung volume was assumed to be three liters and the lung weight was again assumed to be one kilogram.

I shall be very happy if you and the committees you work with can use some of the data presented in UR-298. Please let me know if there is any other information I can furnish you. We are preparing an article for publication that contains some recent data, and I shall send you a copy as soon as it is ready to be submitted.

Sincerely yours,

Jacob Shapiro

Jacob Shapiro

JS b

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7.68
6.57
13.68
2.84

CALCULATION OF LUNG DOSAGE
UR-298, p.121, paragraph 2

1. Average dosage from 25% retention of inhaled daughters in equilibrium with 10^{-11} c/l radon. Minute volume = 10 liters. Assume 1 kg lung

From p. 141 $\quad \text{rem/hr} = \dfrac{26.4 \times \text{liters /min}}{\text{wt. in gm}}$ for 10^{-9} c/l 100% retention

$$\text{mrem/hr} = \frac{0.264 \times 10 \times 0.25 \times 1000}{1000}$$ for 10^{-11} c/l 25% retention

$$\text{mrem/hr} = 6.6$$

2. Average dosage from inhaled radon and daughter products of radon molecules decaying in lungs. Assume 1 kg lung. Lung volume = 3 liters.
Energy of radon family alphas = 19.2 Mev.
10^{-11} curies/liter = 1332 radon disintegrations/hr.

$$\frac{\text{mrem}}{\text{hr}} = \frac{3 \text{ liters}}{1000 \text{ gm}} \times \frac{1332 \text{ dis.}}{\text{hr}} \times \frac{19.2 \text{ Mev.}}{\text{dis.}} \times \frac{1.6 \times 10^{-6} \text{ erg}}{\text{Mev}} \times \frac{1 \text{ rep}}{93 \text{ ergs/gm}}$$

$$\times \frac{20 \text{ rem}}{1 \text{ rep}} \times \frac{1000 \text{ mrem}}{1 \text{ rem}}$$

$$\frac{\text{mrem}}{\text{hr}} = 0.0264$$

3. Recalculation on basis of RBE = 10 for alphas, 1 rep = 100 ergs/gm

Multiply previous values by $\frac{10}{20} \times \frac{93}{100} = 0.465$

Dosage from 25% of daughters = 0.465 x 6.6 = 3.1 mrem/hr

Dosage from radon and daughters in equilibrium = 0.0264 x 0.465 = 0.0123 mrem/hr

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