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cc - R. S. Stone
-Col. Warren
-J. K. Hirth
-K. Z. Morgan
-J. J. Nickson
-Reading File ✓

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TO: Dr. R. S. Stone — Health Director

FROM: J. K. Rose — Health-Physics

RE: Polonium Tolerance

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Since you have requested me to make an estimate of what I might consider a maximum permissible level for polonium X am herewith making an effort to supply such figures in spite of the fact that the experimental data available on which one must base certain assumptions is, to say the least, very incomplete.

If one assumes a ratio of ten for the difference in biological effectiveness of gamma or X versus alpha radiation and it is strongly believed that the ratio is no smaller than this since we now believe that the X-ray or gamma ray versus fast neutrons is about eight, then to calculate the dose of polonium in μc per kilo of tissue one figures as follows, assuming an even distribution in the tissue:

0.01 rep/da. x 1000g $=$ 10 rep/kilo

10 rep/kilo x 2.08×10^9 ion pr./cc air $\frac{(1.05 \text{ dens. tissue})}{(.001293\text{g/cc air})} = 1.7 \times 10^{15}$ i.p./da/k

$\frac{5.3 \times 10^6 \text{ e.v/e disintegration}}{36 \text{ ev/i.p.}^*} = 1.47 \times 10^5$ i.p./dis.

$\frac{1.7 \times 10^{15} \text{ i.p./da/k}}{1.47 \times 10^5 \text{ i.p./dis.}} = 1.16 \times 10^8$ dis/da.

$\frac{1.16 \times 10^8 \text{ dis/da}}{1.44 \times 10^3 \text{ min./da}} = 8.05 \times 10^4$ dis/min

$\frac{8.05 \times 10^4 \text{ dis./min}}{2.22 \times 10^6 \text{ dis/min/}\mu\text{c}} = 0.036\ \mu\text{c/kilo} \cong 0.01$ rep/da

CLASSIFICATION CANCELLED
BY AUTHORITY OF THE U.S. A.E.C. C.O.C
BY Hoyland
DIRECTOR OF TECHNICAL INFORMATION
ARGONNE NATIONAL LABORATORY
DATE 2-13-58 4-16-58 M. McGee

Assume a pair of kidneys weigh 300 grams and even distribution in the kidneys, then:

$0.036\ \mu\text{c/k} \times .3$ k/kidneys $= 0.0108\ \mu\text{c} \cong$ the Max. Permissible Level in Kidneys

The experimental data varied between 3 to 9% in the kidneys and the kidneys seemed to be the limiting organ although the testicles, spleen, and lymph nodes in some of the data at times had concentrations rivaling the kidneys.

Assuming 5% in the kidneys, then:

$\frac{0.0108\ \mu\text{c}}{.05} = 0.216\ \mu\text{c} \cong$ body content

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* See publications of L. H. Gray. Most probable value of $R_\alpha = 36$ ev

1100183

Rose to Stone

June 20, 1945

$2.22 \times 10^6 \times 0.215\ \mu c = 4.8 \times 10^5$ d/min. in body

Certain data indicated a urinary excretion rate of 0.05% per day and Hale used 0.05% - then, using 0.05%

4.8×10^5 d/min. $\times\ 6 \times 10^{-4} = 288 \cong 300$ d/~~min~~ daily in urine = M. P. L.

To determine the air "tolerance" or M. P. L. (maximum permissible level) if one assumes a loss by excretion (urinary plus fecal) of 0.5% per day and adds the loss due to radioactive decay then the loss per day is 1% ; then the half time or half life in the body becomes by:

$e^{-.01} = .99$ and $e^{-.693} = .5$ then

$\frac{.693}{.01} = 69.3$ days and since for practical purposes equilibrium is reached in 5 to 7 half lives then equilibrium is established in less than 1½ years. At equilibrium the amount absorbed is equal to the amount excreted.

Assuming a respiration rate of 8 cubic meters per eight hour day and that 25% of the inhaled polonium is retained in the body, then:

1% of 4.8×10^5 d/m in body = 4800

$\frac{4800}{8 \times .25} = 2400$ d/m/m^3

Allowing for other modes of entry to the body by ingestion, cuts, abrasions, etc., it is felt that 500 d/m/m^3 should be the M. P. L. for air when one wishes to establish a level where so far is known, no detectable damage would result and in general corresponding to the reasoning behind the establishment of the 0.1r per day for X or gamma radiation.

I wish to re-emphasize that the above is based on very tenuous experimental evidence, that the limitations are well realized and when more data is available that the levels should be changed accordingly.

Using data taken from a letter from M. F. Hale to Lt. Col. H. L. Friedell: i.e., 3000 d/da in urine and 0.05% urinary excretion - again if

0.036 μc/kilo = 0.01 rep/da

0.036×70 kg = 2.5 μc in body of a 70 kg man

2.22×10^6 d/m/$\mu c \times 2.5\ \mu c = 5.55 \times 10^6$ d/m in body

$5.55 \times 10^6 \times (5 \times 10^{-4}$ urinary excretion$) = 2780$ d/m daily urinary excretion

With this concentration, assuming uniform distribution, a body receives the "tolerance dose" through out his entire tissue structure. If there is a concentration within the body by a factor of ten (the experimental data indicate cases much higher than ten), then the organ where it is concentrated is receiving ten times the "tolerance" based on 0.01 rep. per day. If the concentration factor is greater than ten then the organ receives an over tolerance dose based on 0.1r/day.

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J. E. Rose