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EXHALATION OF RADON-222 FROM BUILDING MATERIALS AND WALLS AT CONSTANT AND FALLING PRESSURES

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Summary Only
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Exhalation of radon from building materials has been studied by following the build up of activity in closed vessels containing samples of the material.

The main results are shown in the table:

Material	Exhalation Rate $\frac{\text{atoms}}{\text{m}^2 \bullet \text{sec}}$
Slate-based light-weight concretes	1400 - 4000
Ordinary concretes	130 - 180
Clay-based light-weight concretes	20 - 30
Bricks, chipboard, fiberboard, gypsum board	0.3 - 1

For the materials light-weight concrete and bricks, the exhalation rate is found to be proportional to the mass (or volume) of the material rather than to the surface area.

On the basis of a linear diffusion model the porosity, diffusion length and radon production rate is found for a slate-based light-weight concrete (with a radium content of approximately 5 pg/g) by measuring the exhalation at various (constant) pressures.

The model also predicts that with the geometry of samples and vessels used in these experiments the exhalation rate derived from the equilibrium activities might be approximately 10% lower than the values corresponding to exhalation into an infinite space.

The exhalation of radon from walls was measured in a concrete-walled basement room by studying the growth of activity in exhalation cans sealed to various portions of the walls. The average of 53 measurements gave an exhalation rate at atmospheric pressure of

$$E_o = 379 \pm 107 \ \frac{\text{atoms}}{\text{m}^2 \bullet \text{sec}}.$$

In a series of measurements, constant underpressures from 5 to 25 mm Hg were maintained in the exhalation cans during the build up of activity. The results of the measurements are shown in Fig. 1. It appears that the exhalation rate E can be expressed as

$$E = \frac{dE}{d\Delta P} \cdot \Delta P + E_o = m\,\Delta P + E_o \qquad (1)$$

where

$$m = \frac{dE}{d\Delta P} = 91 \frac{\text{atoms}}{m^2 \cdot \text{sec} \cdot \text{mm Hg}}.$$

For the room of emanating area A = 360 m^2 and air volume 324 m^3, the steady state E_o-value is capable of supporting a room air radon concentration of 4.8 ± 1.4 pCi/l. This compares well with the mean radon concentration over a 5 month period of 6.9 ± 1.7 pCi/l, with maximum values in the region of 15 pCi/l measured on occasions followin large atmospheric pressure drops.

In the theoretical considerations of pressure drops it is assumed that the basement concrete walls in toto are capable of sustaining for many hours underpressure - enhanced E values comparable to those experimentally measured at various places on the walls. Corroboration for this viewpoint was obtained by determinations of the effective diffusion coefficient of radon in the walls and estimations of the partitioning of radon between the wall material and the room air.

The effective decay constant, λ^*, for radon in the room under typical conditions was approximately 3×10^{-4} min^{-1}. The room was found to have a small natural ventilation rate of 2.25×10^{-4} min^{-1} with the presence of make up air coming from adjacent rooms having a partially compensating effect.

Taking for convenience the room air activity initially to be at its equilibrium value of

$$\lambda N_o = \frac{\lambda}{\lambda^*} A \cdot E_o$$

it can be shown that the fractional increase in activity due to a pressure drop of total magnitude ΔP whose establishment takes place at a constant rate over a time t_f is

$$\frac{\Delta(\lambda N)}{\lambda N_o} f\_ = \frac{m\Delta P}{E_o} \; 1 - \frac{1 - e^{-\lambda^* t_f}}{\lambda^* t_f} \qquad (2)$$

Fig. 2 is obtained using equation (2) for hypothetical but realistic situations where a pressure drop of total magnitude ΔP = 20 mm Hg takes place in the basement room at a constant rate for various t_f-values up to 36 hours. The values of E_o, m and λ^* given above are used.

It can be seen from the figure that the activity is doubled if it takes approximately 27 hours for the full pressure drop to occur. This is in keeping with observations on the room air radon levels over a number of months.

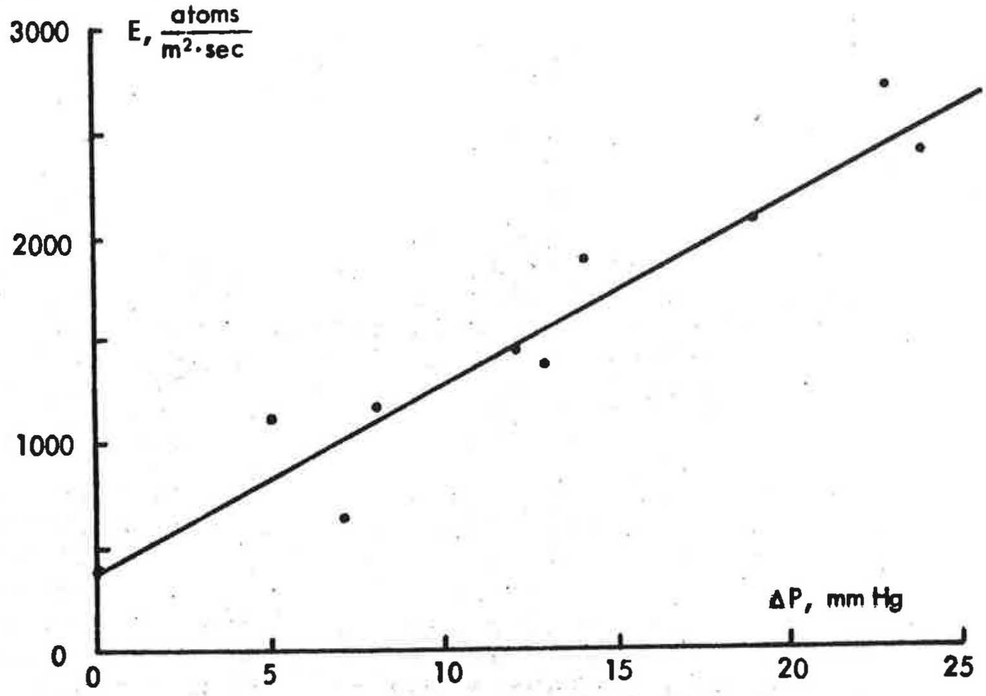

Fig. 1. Exhalation rate E as a function of the underpressure ΔP.

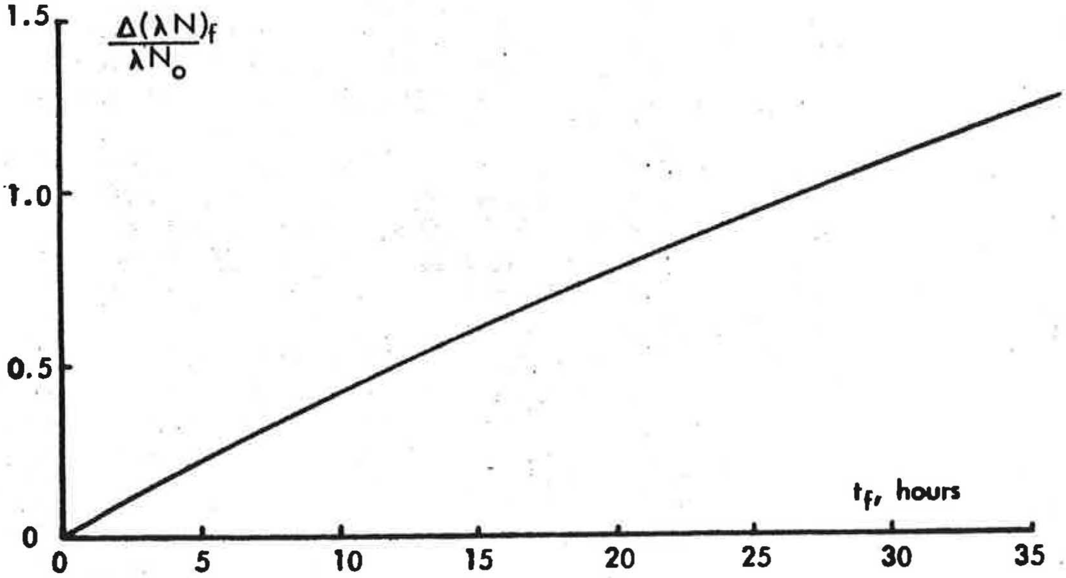

Fig. 2. Fractional increase in total room activity for a pressure drop of 20 mm Hg as a function of the pressure drop establishment time.