ACTINIDE-IN-AIR MONITORING IN THE PRESENCE OF RADON & THORON

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This paper describes further developments of a computer code[1] which calculates the expected count rate in the plutonium channel of an actinide-in-air monitor from radon/thoron daughters. All the major pathways of radon/thoron into a building are allowed for; calculations are performed as a function of ventilation and recirculation rates.

OPERATION OF THE MONITOR

Commercially available continuous actinide-in-air monitors work by drawing air through a filter paper; this retains any particulate or free radon daughter activity. The filter paper is surveilled by a surface barrier semiconductor detector located in the incoming airstream a few millimetres above the deposited activity. In ideal counting conditions the pulse height spectrum would be composed of a number of narrow peaks corresponding to emitted α-energies. However, in the practical system the spectrum is composed of a number of broad bands because of random energy degradation: the α-particles travel across the air gap between filter paper and detector in random directions and therefore lose different amounts of energy. There are other possible sources of degradation including passage through filter fibres and any accumulated dust.

It is therefore not adequate simply to measure the count rate in a particular incident energy range; as can be seen from Figure 1, the overlap between the radon daughter spectrum and that from plutonium-239 is extensive. The only reliable way in which the actinide can be detected is to compensate, in some way, for the presence of the radon daughters. In the 3280 this is done by making a number of measurements at higher energies, to establish the radon daughter contribution, and using these to subtract an appropriate amount from the count rate measured in the actinide energy region.

Although this process works quite effectively there remains some advantage in controlling the radon level in the working environment. The model described here allows examination of the effects of various factors on the radon daughter count rate.

THE THEORETICAL BASIS OF THE MODEL

The individual radon daughter air concentrations are estimated, using source term specification procedures discussed below, with a steady-state version of the set of equations derived by Porstendorfer[2]. These account for the effects of radon daughter attachment to particulates and to surfaces, detachment from particulates, radioactive decay and ventilation. They allow for constant sources of radon, such as direct exhalation into the room as well as entry with ventilation air. They have been extended to include recirculation and to allow for filtration of both makeup and recirculating air[1].

The steady-state activity of daughter j on the filter paper of a monitor sampling $V m^3 h^{-1}$ is:

$$S_j = \frac{V(C_j^{(a)}+C_j^{(f)}) + S_{j-1}}{\lambda_j}$$

where $C_j^{(a)}$ and $C_j^{(f)}$ are the concentrations in air of attached and free particles (both are assumed collected by the filter paper and is the decay constant of daughter j. Since radon is not collected, $S_o = 0$.

The fraction of the counts from each alpha emitting daughter (of radon and thoron) which appears in the actinide energy region have been estimated using a relationship described in reference 1.

SOURCES OF RADON

The entry of radon with ventilating air, filtered or unfiltered, is included in the basic equation; the user may therefore specify the appropriate concentrations.

The model includes a number of options for describing radon ingress through floor intact slabs with and without damp proof membranes using diffusion theory. However the importance of penetrations as sources of radon has been recognised in recent years. The model includes a simple representation of these features although, as yet, it does not account explicitly for interactions with ventilation characteristics. Exhalation from walls is included, either through solution of the diffusion equation or by input of direct measurement information[3]

Thoron exhalation is included in the model; its representation is somewhat simplified because its short half life results in only a thin surface layer being effective.

THE IMPLEMENTATION OF THE MODEL

The basic computer code PLURAD has been implemented on a number of micro-computers; it is used principally on a Research Machines Ltd 380Z, a 64 Kbyte machine. The results are displayed as coloured graphs and these are reproduced on a plotter. A typical output from the program is shown in Figure 2.

CONCLUSIONS

The model includes most of the significant features with a background for actinide-in-air monitors. The computer program hsa proved useful in the evaluation of effectiveness of options for radon/thoron control in a number of active facilities. Although primarily designed for use in the analysis of problems associated with air monitoring in active facilities, where air change rates are generally high, it is adapable to a wide range of situations where airborne natural radioactivity is a concern.

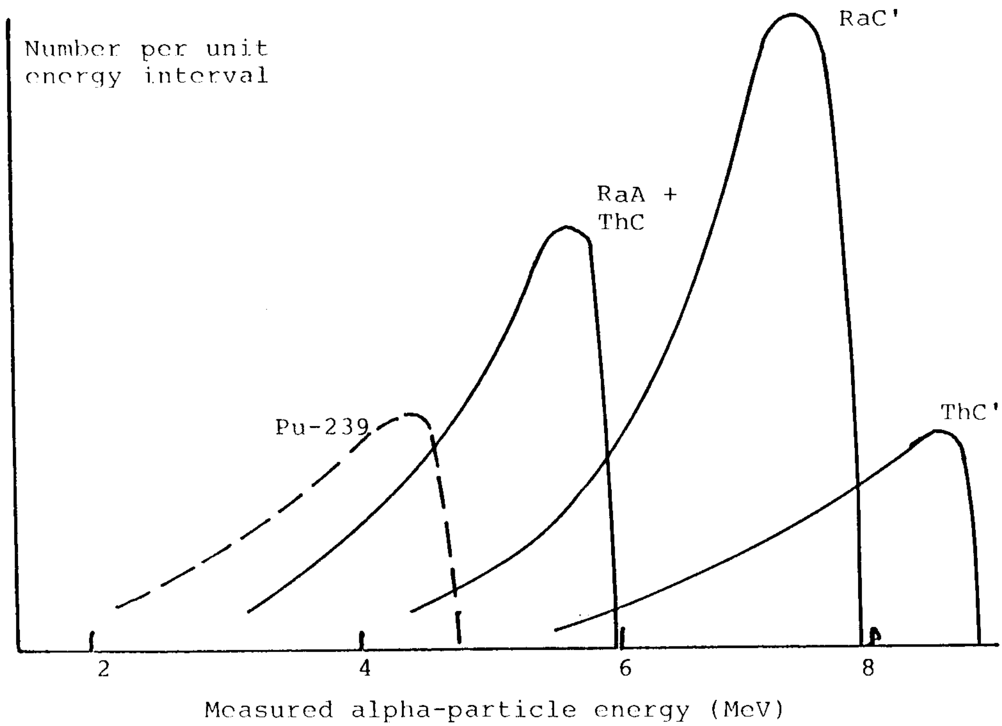
REFERENCES

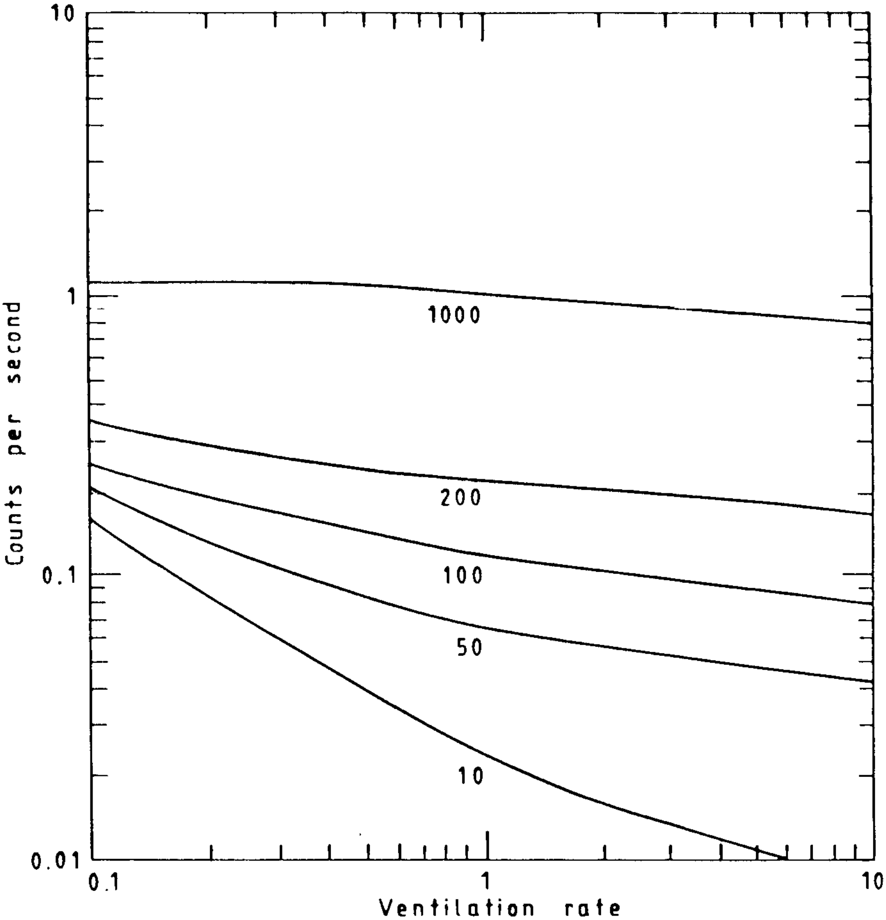
1 MEGGITT G C and WALKER B C. PLURAD: A computer program to predict the background for actinide-in-air monitoring in buildings from radon isotopes. SRD R218 (1981).

2 PORSTENDORFER J, WICKE A and SCHRAUB A. The influence of exhalation, ventilation and deposition processes upon the concentration of radon (Rn-222), thoron (Rn-220) and their decay products in room air. Health Physics 34, P456 (1977).

3 CLIFF K D, MEGGITT G C, RHODES T and RYDEN D J. The standardisation of radon and thoron emanation measurements. UKAEA Report, SRD R298 (1984).

Figure 1: Illustrative Energy Distribution of Measured Alpha Particle Energies





Outdoor radon concentration = 10 − 1000 pCi m^{-3}
Outdoor thoron concentration = 10 − 1000 pCi m^{-3}
Recirculation rate = 0 hr^{-1}
Ventilated air is filtered : filter efficiency = 90 %
Height of building = 10 m
Length of building = 30 m
Width of building = 20 m
Radon exhaling from walls = 200 pCi m^{-2} hr^{-1}
Thoron exhaling from walls = 400 pCi m^{-2} hr^{-1}
% radon passing through paint = 20
% thoron passing through paint = 0
Soil Ra − 226 concentration = 1 pCi g^{-1}
Concrete Ra − 226 concentration = 0.8 pCi g^{-1}
Floor thickness = 40 cm
Radon diffusion coefficient in dpm = 10^{-8} cm^2 s^{-1}
Thickness of dpm = 0.02 cm
Distance between dpm and surface = 15 cm
Thoron exhaling from floor = 200 pCi m^{-2} hr^{-1}

Figure 2: Count Rate in the Plutonium Channel of a Harwell Type 3280 Plutonium-in-Air Monitor from Radon & Thoron Daughters with Various Outdoor Radon/Thoron Levels. Incoming air is filtered.