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Hans VANMARCKE

Health-Physics Measurements

Radon in the Indoor Environment

Scientific staff
Johan PARIDAENS
Hans VANMARCKE

Supporting staff
Jean-Pierre ALZETTA
Paul WILLEBORTS

CURRENT ASSESSMENTS of health risks due to radon are based on epidemiological studies of underground miners. A consensus is growing that this is a questionable practice, and efforts are being shifted towards a different approach. There is a growing interest in performing epidemiological studies on the general population, thus raising the question of assessing past radon exposures for such populations. On the other hand, growing efforts try to measure directly the amount of deposited radon progeny in different areas of the respiratory tract.

Objectives

- to investigate the deposition of radon progeny in the human respiratory tract by means of direct measurements as a function of aerosol conditions;
- to assess the radon concentrations in buildings retrospectively with volume traps.

Programme The programme foresees the direct measurement of deposited radon progeny in the human respiratory tract by means of the bronchial dosemeter, an instrument simulating the airflow in the respiratory tract. In a first stage, these measurements will take place in the well-controlled environment of a reference chamber, and in a second stage in real field conditions (actual dwellings).

The retrospective assessment programme consists in the development of the volume-trap technique, and is carried out in the framework of the Radiation Protection Research programme of the EC, more precisely as part of one shared-cost action and two concerted actions.

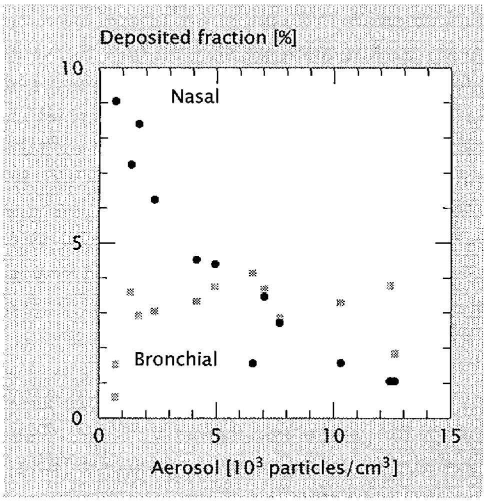
Achievements In 1997, we calibrated the new measuring heads, developed to adapt the bronchial dosemeter to the newly constructed radon reference chamber. These calibrations had to be done with the utmost accuracy, because the results of the individual measuring heads have to be subtracted from one another to assess the deposited fractions in different parts of the respiratory tract. We therefore performed both relative and absolute calibrations. The relative calibrations consisted in sampling the same mixture of radon-daughter concentrations with the three heads simultaneously. This yielded the relative response of the measuring heads: 1.00 : 1.056 : 1.055. Absolute calibrations were made by means of subsequent alpha and gamma spectroscopy. The gamma spectroscopy measurements were calibrated absolutely by means of a calibrated gamma source of the same geometry as the measuring heads. They yielded absolute efficiencies of 13.1, 13.8, and 13.8% for the three measuring heads respectively, showing nice agreement with the relative calibrations.

For the study of radon-progeny behaviour in radon chambers, we participated in an intercomparison exercise organized in the animal exposure chambers of the *Laboratoire de pathologie pulmonaire expérimentale* (LPPE) in Razès, near Limoges, France. Participants from Spain, Germany, France, Sweden, the United Kingdom, and Belgium measured radon concentrations, equilibrium factors, and attached and unattached fractions of radon decay products for various conditions in the two animal exposure chambers and in a separate animal room. We also used our bronchial dosemeter to assess the fractions of each of the radon decay products deposited in the nasal and bronchial tract, for each of the conditions. One of the purposes of this exercise was to assess the influence of the presence of rats on the abovementioned parameters. We found equilibrium factors between 0.18 and 0.47, nasal fractions between 2.0 and 16.8%, and bronchial fractions between 2.1 and 6.7% of total equivalent equilibrium concentration. No significant differences were seen between results with or without rats present. All of the results are being elaborated centrally, and conclusions are expected shortly.

Figure 1 shows a typical curve for the deposited fraction of the equivalent equilibrium concentration as a function of the aerosol concentration in our own radon chamber. Future measurements will allow a better understanding of the behaviour of radon decay products under various conditions.

Within the framework of the Radiation Protection Research programme of the EC, we made further efforts to extend the applicability of our volume-trap technique for assessing radon

Figure 1 The deposited fractions of the equivalent equilibrium concentration as a function of the aerosol concentration in the SCK•CEN chamber. The nasal fraction increases markedly as the aerosol concentration diminishes.



exposures in the past. More specifically, due to the great difficulties encountered in some areas to find spongy volume traps, we tried to extend the technique to other materials, such as wood or fibreboard. For this purpose, we performed new laboratory radon exposures on these two materials, with emphasis on using different types and densities of wood and fibreboard, of different sizes and shapes. The idea was to see if a simple relationship between density, radon exposure, and measured ^{210}Po activity could be found. The first results unfortunately indicate otherwise. It might however be possible to develop a simple test of relatively short duration (a few days) to estimate fairly accurately the relationship between radon exposure and detected ^{210}Po activity for each separate sample. Therefore all samples were first exposed separately to radon. From subsequent exhalation data, information can be gained about the expected ^{210}Po activity in the sample. We will further investigate if this simple, straightforward test works for potential volume traps of various kinds.

Another important characteristic of a good volume trap is the speed at which radon can diffuse through the material. This has been tested for several types of sponges and for wood and fibreboard samples. The results were excellent for all of the considered sponges and still very acceptable for the wood and cardboard samples. As we found, radon diffuses throughout sponges in only minutes, and through wood and cardboard in typically a few hours. These times are always short compared to the lifetime of radon itself, which is a necessary condition for the good functioning of a volume trap.

All of this has largely increased our competence in retrospectively assessing past radon concentrations, making SCK•CEN a valuable partner for future epidemiological studies.

Partners, sponsors, and customers

Scientific partners Universiteit Gent (UG) — University of Lund — Swedish Radiation Protection Institute (SSI) — University College of Dublin — Commissariat à l'énergie atomique (CEA)

Sponsor European Commission (EC), Radiation Protection Research programme, DG XII

Scientific output

Presentations delivered in 1997

J. PARIDAENS, H. VANMARCKE, "Semi-Automatic Counting System for Reading out Radon Measurements," European conf. on Protection against Radon at Home and at Work: Praha, Czech Republic, June 2-6, 1997. Proc., 164-167.

F. TONDEUR, I. GERARDY, A. POFFIJN, G. MEESSEN, H. VANMARCKE, J. PARIDAENS, S. OBERSTEDT, S. HALLEZ, J.M. FLEMAL, A. DEBAUCHE, C. DE LELLIS, "Belgian Intercomparison of Solid-State Radon Measurements," European conf. on Protection against Radon at Home and at Work: Praha, Czech Republic, June 2-6, 1997. Proc., 262-266.

H. VANMARCKE, M. VERLAAK, J. PARIDAENS, "Radon Concentrations in Limburg (Belgium)," European conf. on Protection against Radon at Home and at Work: Praha, Czech Republic, June 2-6, 1997. Proc., 276-279.

Report published in 1997

J. PARIDAENS, "Semi-Automatic Counting System for Reading out Radon Measurements," SCK•CEN report (January 1997). BLG-729.