The influence of the working conditions on the equilibrium factor F and the unattached fraction fp (*)

T. STREIL (1), A. REICHELT (2) and A. REINEKING (3)

(1) *SARAD GmbH - Dorfplatz 1, D-01705 Pesterwitz/Dresden, Germany*
(2) *TÜV Süddeutschland - Westendstr. 199, D-80686 München, Germany*
(3) *Georg-August Universität Isotopenlab. - Burckhardtweg 2, D-37077 Göttingen, Germany*

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Summary. — We report on the influence of the working conditions on the dose estimation. Especially the equilibrium factor and the unattached fraction are influenced by the working conditions. For instance in a cabinet-maker's shop the radon concentration is strongly influenced by the ventilation system. The factor F is influenced by dust-producing work processes. For a better knowledge of the radon dosimetry it is also necessary to measure continuously and separately the unattached fraction of the radon progeny. We present first results obtained with a SARAD EQF 3020 monitor which contains three alpha detector microsystems measuring radon in the air, attached radon daughters and unattached radon daughters. The three components are measured quasicontinuously with a temporal resolution of 2 hours. The measuring range is 1 to 10 MBq/m^3 at a low detection limit of 0.1 Bq/m^3 equivalent radon concentration. The system was tested in buildings, caves, mines, waterworks and other places. By using silicon microsystems with alpha detector, ADC, memory and logics—which are integrated on few chips—the costs for the production of equipment are far lower than if produced by means of assembled individual components.

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1. – Introduction

The influence of the working conditions on the dose estimation is very important. Especially the equilibrium factor and the unattached fraction are influenced by the working conditions.

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For instance, in a cabinet-maker's shop the radon concentration is considerably influenced by the ventilation system. The factor F is influenced by dust-producing work processes.

For a better knowledge of the radon dosimetry it is also necessary to measure continuously and separately the unattached fraction of the radon progeny. The dose factors for unattached radon daughters are considerably higher than for radon daughters attached to aerosols. Therefore dose calculations and assessments of remedial actions based only on radon gas or attached radon daughter concentrations may be misleading. Reducing, *e.g.*, the aerosol concentration by aerosol filters, the attached fraction is clearly reduced but the unattached fraction increases, resulting in a dose increase instead of a dose reduction.

One of the reasons why one rarely measures all three components (radon, attached fraction and unattached fraction) is that there are no cheap portable instruments available which can measure them all. A monitor built out of alpha spectrometric silicon microsystems is reported in [1]. The first step to use microsystems for the radiation detection was the application of special designed d-RAM cells [2]. These systems were only applicable for counting and not for spectrometry. The small size and the low power consumption of silicon microsystems also make them ideal for portable instruments. We present first data obtained only with this type of monitor containing three detectors and measuring all three components with a temporal resolution of 2 hours.

2. – Methods

In a previous paper we have described a radon and radon progeny monitor allowing the simultaneous measurement of radon and radon progeny with two silicon microsystem detectors [3, 4]. In this system the air passes an aerosol filter registered by the first detector and then flows through the radon measuring chamber. We now have added a metal screen/detector assembly that can be switched into the air flow in front of the aerosol filter to catch and measure the unattached radon daughters. A microprocessor controls the movement of the two radon daughter detectors and the screen. The cut-off factor of the screen at an air flow of 2.5 l/min and the screen geometry is 5 nm. We are thus able to measure radon progeny and attached progeny separately [5].

3. – Results and discussion

Figure 1 shows a long-time measurement of the radon concentration, the attached and the unattached progeny concentration in a cabinet-maker's shop. The daily variations can be seen clearly. In the morning the ventilation system is switched on and in the evening the ventilation system is switched off. At a high ventilation rate the unattached fraction is increased but in the evening—due to the small ventilation rate and the dust-producing production processes—the attached fraction is increased. In the dusty production rooms this fact is excellently shown (especially during the weekend) in fig. 1. On Monday, early in the morning, the ventilation reduces rapidly the aerosol concentration, and the factor fp increases (fig. 2). When the production process starts, the dust increases the aerosol concentration as well as the factor F.

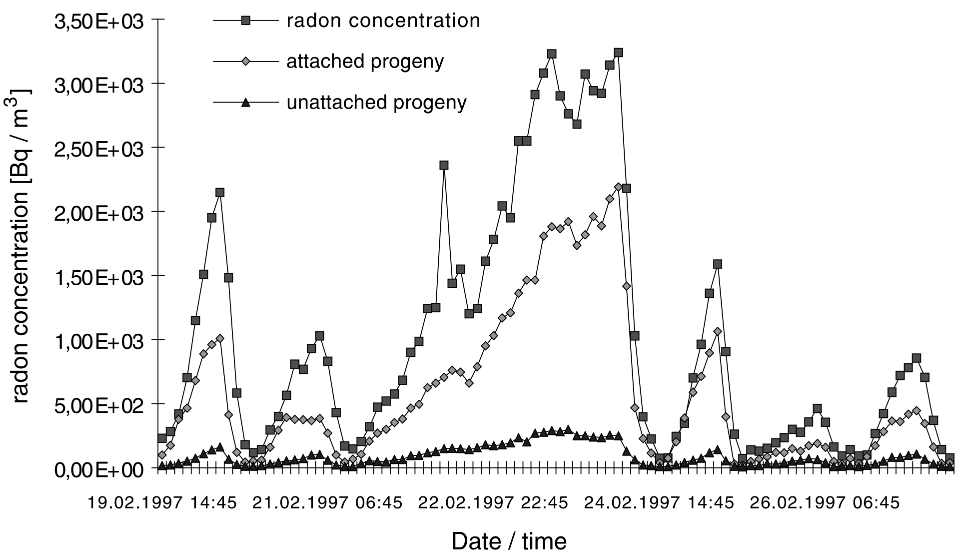

Fig. 1. – Radon and progeny concentration in a cabinet-maker's shop.

Figure 3 shows a measurement carried out in Dresden (Germany) concerning the equilibrium factor F and fp of the unattached fraction at a work place in a school cellar next to the coal heating system.

The big variation of the fp factor is caused by the change of the ventilation rate and the aerosol concentration in this cellar. The radon and radon progeny concentration is shown in fig. 4. The factor fp ranging up to 0.11 shows that for the dose calculation the

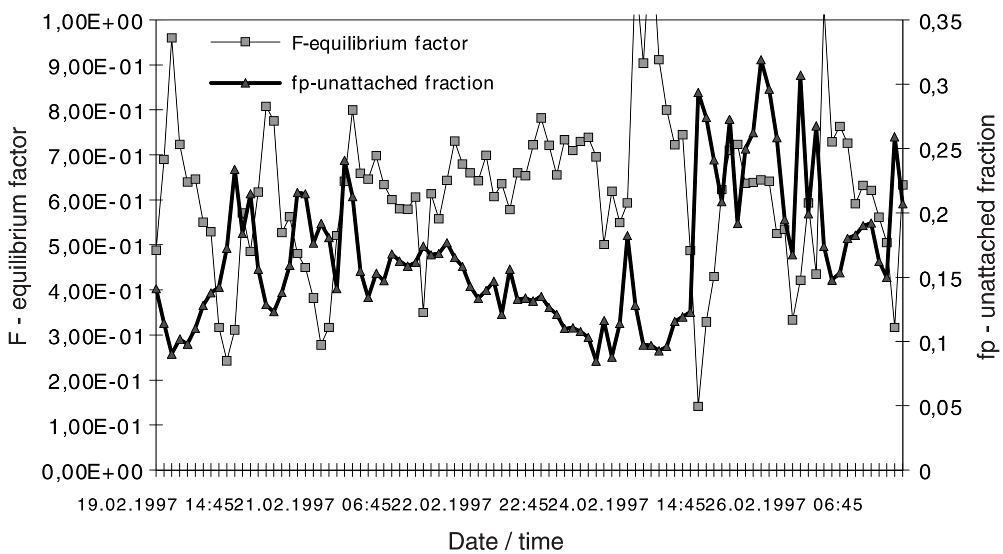

Fig. 2. – Equilibrium factor F and fp in a cabinet-maker's shop.

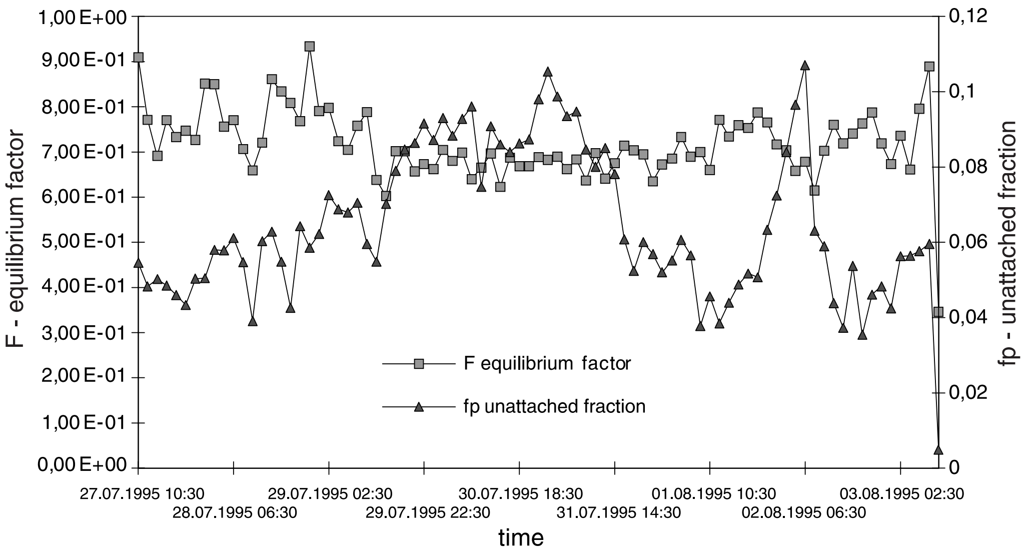

Fig. 3. – Measurement of the equilibrium factor F and fp in a school cellar in Dresden.

unattached fraction is not negligible. A long-term study in this place shows that the average value of the unattached progeny concentration is in the order of 200 Bq/m^3 and the attached progeny concentration is of approximately 2000 Bq/m^3. Using the James/Birchel lung model (recommendation of ICRP 66) for the dose calculation, the exposed person (the stoker) accumulates during 2000 working hours approximately 28 mSv/a from the unattached progeny and 32 mSv/a from the attached progeny. In

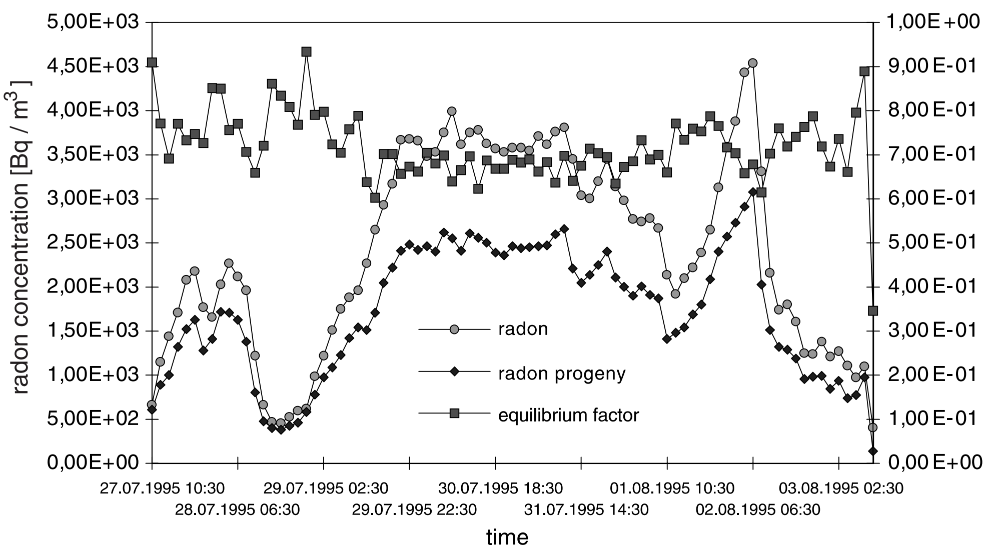

Fig. 4. – Measurement of radon and progeny concentration in a school cellar in Dresden.

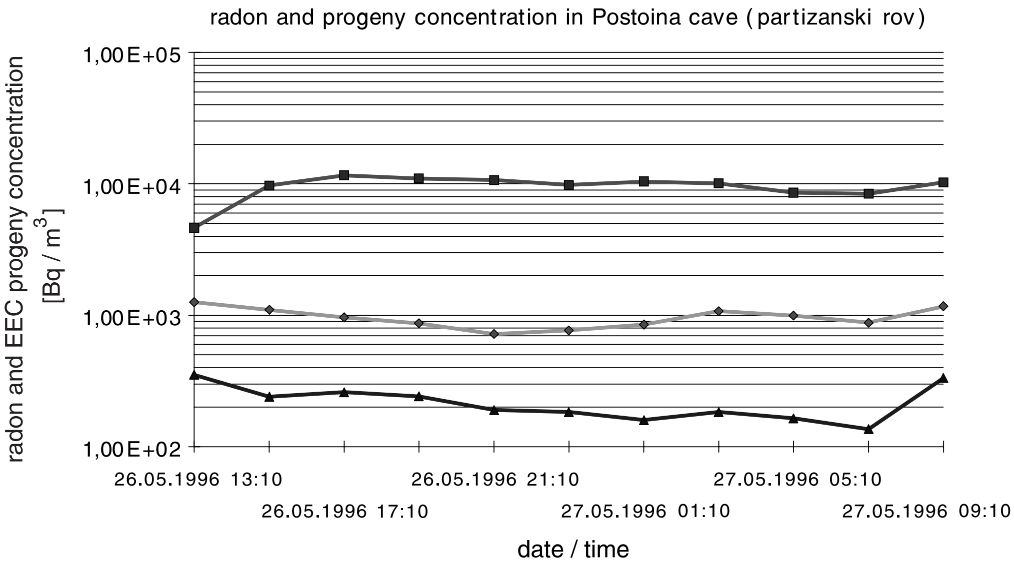

Fig. 5. – Radon and progeny concentration in a show cave.

this way we can conclude that the unattached fraction has almost the same dose contribution as the attached fraction at this work place.

Using this new measuring technique it is possible to get more exact information of the real dose at work places or other interest places.

Another work place is shown in fig. 5 and 6. In collaboration with Ivan Kobal and

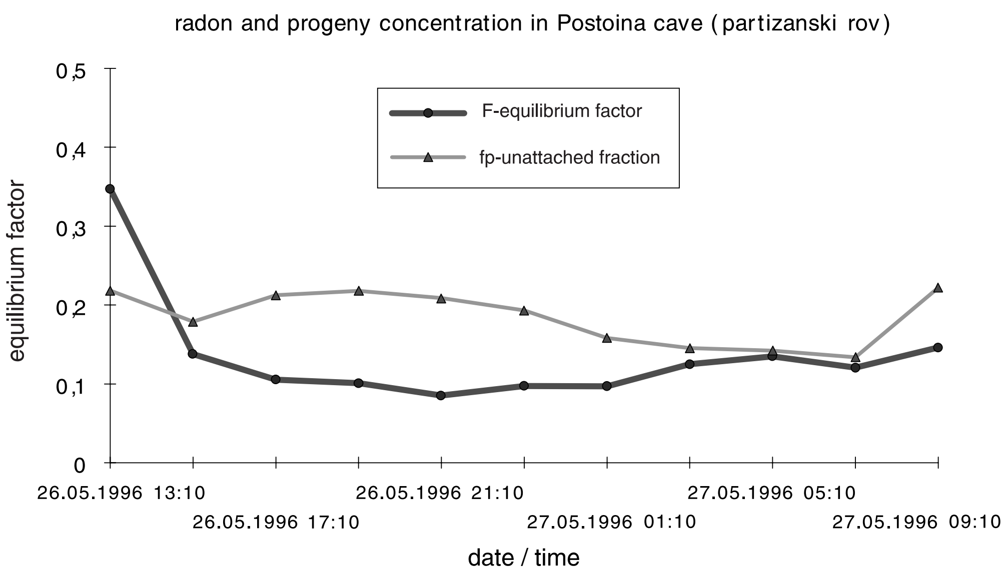

Fig. 6. – Equilibrium factor F and fp in a show cave.

Janja Vaupotic from the "Jozef Stefan" Institute in Lublijana (Slovenia), we measured the radon, attached and unattached progeny concentration in the Postoina show cave in several places. Especially in the place "partizanski rov" we measured a very low factor F in the order of 0.1 (fig. 6). This low factor F is caused by the extremely clean and aerosol-free air and the natural ventilation in this cave. In this case the main contribution for the dose of the tour guides resulted from the unattached progeny with approximately 30 mSv/a during 2000 working hours.

The contribution of the attached fraction is of approximately 15 mSv/a. In this cave the usual working hours for the guides are 10 hours per day and in this way the above-mentioned dose estimation reflects the almost real conditions.

This first study shows that at work places the working conditions have a strong influence on the real dose of the worker due to the radon progeny. We found places with very low factors F of approximately 0.1 and dusty places with high factors F of approximately 0.8. The unattached fraction fp varies considerably from 0.02 in waterworks [6] up to 0.3 in ventilated rooms.

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