VENTILATION TECHNIQUES AND RADON IN SMALL HOUSES

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INTRODUCTION

Indoor radon is the main cause of radiation exposure in Finland. The National Board of Health set the recommended concentration limits in 1986: an action level of 800 Bq/m^3 and a planning value of 200 Bq/m^3 for new buildings. According to Castren et al. (2), the 800 Bq/m^3 concentration is estimated to be exceeded in 1.4 % of the housing. This rather high number has motivated a number of studies concerning countermeasures against radon in existing houses.

In general, the primary types of countermeasures reported have been: locating and sealing of radon penetrations, sub-floor ventilation (or depressurizing) systems and increased ventilation (e.g.3,4,5,11,12,13). In cost-benefit studies best applicable to the Finnish circumstances, the sub-floor measures have been found to be normally superior to the ventilation measures (3). The use of ventilation measures may, however, be reasonable when the existing ventilation rate is very small. An important point often neglected is the beneficial effect of increased ventilation on the general indoor air quality.

Our approach to the radon problem is based on the foundings of a large national indoor air survey (7,8), which clearly indicated poorly designed or adjusted ventilation systems to be common. A large variation was observed in the air exchange rates: although the ventilation rates in average were acceptable, the air exchange rates in a large number of small houses were found to be very small and well below the limits set by the Construction Code. One reason for the low flow rates are the poor (non-existing) supply air systems which were found to be common. The increased underpressure due to the lack of supply air inlets often contributes to high radon concentrations even if the exhaust system is capable of producing an adequate ventilation rate. This is caused by the pressure-driven radon flow through the sub-surface structures (1,9,10). It is evident that a number of houses exist where problems are encountered with indoor air impurities, whenever the impurity source is enhanced. In addition to radon, high concentrations of CO_2 in bedrooms have been observed.

The purpose of this study was to find out possible remedial actions against radon using standard ventilation techniques. The ventilation rates were not increased over 0.7 1/h in order to have a realistic view about the possibilities of the state-of-the-art techniques. Special attention was given to methods which would be generally applicable to a large number of dwellings already existing. Results are reported of a pilot study with six small houses with established high radon concentrations.

EXPERIMENTAL

The six measurement sites were selected from a larger sample of dwellings, where high radon concentrations had been measured. The studied dwellings represent different types of construction and ventilation techniques. Table 1 shows some basic data about the houses. The summer and winter radon concentrations were measured by the Finnish Centre for Radiation and Nuclear Safety using solid state nuclear dosimeters.

Table 1. Measuring sites.

Site	Rn, Bq/m^3 Summer/Winter	Construction year	Total floor area, m^2	Stores	Ventilation
1	470/1840	83	173	2	exhaust
2	1280/1960	85	216	2	supply/exhaust
3	1265	84	216	2	exhaust
4	1430/1960	29	103	3	natural
5	250/1810	83	115	1	natural
6	280/430	80	104	1	supply/exhaust

Continuous monitoring of radon was performed using meters constructed in our own laboratory (6). Air exchange rates, air flow rates and pressure differences were also measured. Meteorological conditions — wind direction and speed, temperature and atmospheric pressure were obtained from the data registers of a nearby weather station.

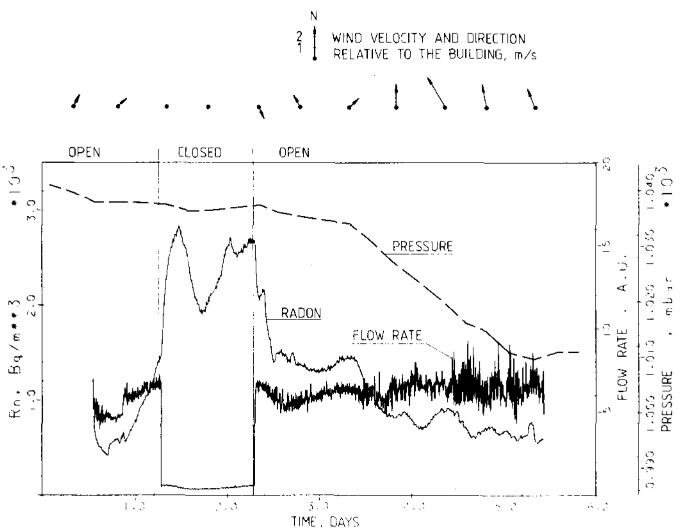

Figure 1. The effect of the valve of the supply inlet installed in house 1 on the radon concentration. The effect of atmospheric conditions on the concentration and on the flow rate is also evident.

The remedial actions ranged from opening an obstructed air inlet to installation of complete ventilation systems. Two major types of commercial systems were used, both constructed to minimize the underpressure in the building: balanced mechanical ventilation with heat recovery and passive supply inlets with electric heating. The supply inlets produce a relatively large flow rate at a low pressure drop. The heating of the supply air is essential during the wintertime. No measures were performed in site 6, whereas the others were subject to following:

Site 1. The ventilation was re-adjusted. A supply air heater was installed downstairs (air ducted in to the two bedrooms). The effect of the inlet on the radon concentration is shown in Figure 1, as is the effect of atmospheric conditions on the flow rate through the device.

Site 2. The ventilation was adjusted and the obstructed major supply air inlet opened.

Site 3. A mechanical supply/exhaust ventilation system was installed, utilizing the existing exhaust ducting.

Site 4. Routes of radon entry from the soil sealed, an exhaust fan and a supply air intake with heater installed.

Site 5. A mechanical supply/exhaust system installed. Figure 2 shows the effect of the system on the radon concentration.

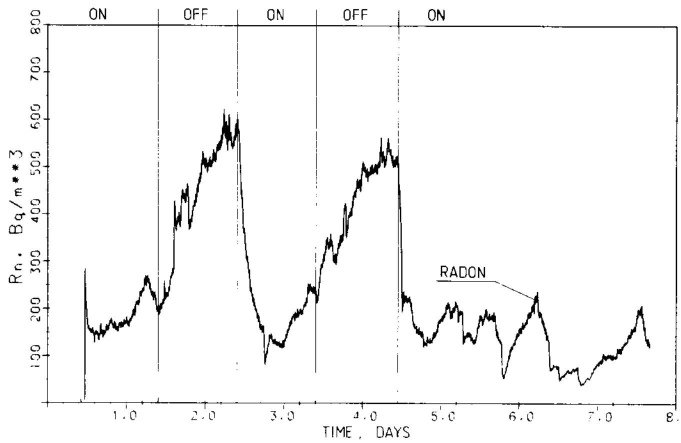

Figure 2. The effect of the installed supply/exhaust ventilation system on the radon concentration in site 5. The ventilation rate, while system OFF, is approximately the same as before the installation.

RESULTS AND DISCUSSION

Table 2 shows the obtained concentration decrease in the five dwellings and the approximated maximum costs including planning, equipment, installation and adjusting. The running costs are not presented, but were at maximum in site 5: approximately 500 FIM/year.

Table 2. Obtained decreases in the radon concentration and approximated total costs.

Site	1	2	3	4	5
Concentration decrease %	70*	40*	50	70	75
Total cost (FIM)	4700	1000	12000	8500	14000

*in bedrooms

The concentration decrease is a good approximation for wintertime. During summer the decrease is expected to be smaller. Observed large momentary deviations in the radon concentration set demands for the measurement of the effect of the measures. The on-off method used here combined with a long-term integrating measurement is believed to give reliable results. Because of the sometimes large yearly variations measurements should also be done in different seasons. The best results were obtained in sites 1, 2 and 5, where the decrease in the radon concentration was equal or better than the increase in the ventilation rate. In multi-stored houses 3 and 4 (partly below the surface level) complete control of the air could not be achieved with the simple systems used.

CONCLUSIONS

Although not extensive, the preliminary study shows that the use of standard, commercially available (balanced) ventilation equipment may be a cost-effective alternative as a remedy against high radon concentration. Apart from the reduction in the radiation exposure, these methods have other beneficial effects: decrease in the concentration of all indoor-source impurities as well as increased living comfort. It should also be remembered that the decrease in the potential alpha energy concentration obtained by increased ventilation is normally larger than the decrease in the radon concentration. The example of site 2 shows that the existing ventilation system should always be inspected to ensure proper functioning before other countermeasures take place.

It is evident that increased ventilation is a cost-effective measure only in houses where the existing air exchange rate is small and/or the increase can be easily obtained. It is equally evident that there is a considerable amount of houses in Finland fulfilling at least the first condition. The next step is to find out if it is possible to characterize these dwellings so that they may be identified without extensive studies on the basis of basic data about the construction. Obtaining simple model solutions with installation instructions for these houses is the final object of the extension study.

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