Environmental Radon Newsletter

SPRING 2006 ISSUE 46

UK radon forum

Jon Miles, Health Protection Agency (jon.miles@hpa-rp.org.uk)

The 2005 UK radon forum was held in December at Chilton in Oxfordshire, at the headquarters of the Radiation Protection Division of the Health Protection Agency (HPA-RPD). The 70 people who attended the meeting came from all over the UK and Eire, and their questions showed a keen interest in the issues raised by the speakers.

The meeting opened with a review of the health risks of radon by the deputy director of HPA-RPD, Jill Meara, including a discussion of the results and implications of the recent epidemiological studies of domestic radon exposure and the risk of lung cancer. She pointed out that the new results demonstrated a significant risk below the current UK Action Level for radon of 200 Bq m^{-3}. She ended with three questions arising out of this finding:

- Should preventative measures be more widespread?
- Should the Action Level be lower?
- Should campaigns for measurement/ remediation be guided by Health Economics considerations?

Overviews of radon programmes in Wales, Northern Ireland, Scotland and England were presented by Ronnie Alexander, Robert Larmour and Martyn Green. Each included a history of the radon programme, current progress and proposed future actions. The programmes had reached different stages in different parts of the UK, but all had regulations in place aimed at preventing high radon levels occurring in new houses built in those areas found to be most at risk. Mapping to identify the high radon areas in Scotland was expected to be completed and published in 2006.

Progress on detailed mapping of England and Wales by HPA and the British Geological Survey was presented by Jon Miles. This showed variation in radon potential both between and within geological units, and would be published in 2006. The map would be used in answering the 'CON29 radon question' asked by lawyers during house purchase, and to identify areas where radon protection was needed in new buildings.

Gareth Thomas showed the national enforcement strategy being used by the Radiation Team of the Health and Safety Executive. Enforcement was carried out in four stages where necessary: Informal, Improvement notice, Prohibition notice, and Prosecution. The strategy for 2005-2010 was employing 13 different initiatives, many of them based on suggestions from participants in the previous UK radon forum.

David Gell presented the experience of Ashfield in achieving radon remediation of private and public sector housing. Unusually, this included a policy decision to offer 100% non-repayable grants where remedial action was required. The programme had been very successful, with a high success rate and an average cost of £845 per house remediated. It fitted very firmly with the Council's aims, and was regarded as probably one of the best uses of capital finance using Regulatory Reform Order powers.

Preventive measures in new buildings

A significant theme emerged during the meeting: the effectiveness (or possible lack of effectiveness) of radon preventive measures in new buildings. This issue was addressed by Tony Denman, Brian Ahern, Peter Lilley, Chris Scivyer and Mike Johnson. Evidence was presented that preventive measures were sometimes improperly installed, and could sometimes fail to keep buildings below the Action Level. Lack of understanding, inadequate supervision and inspection, and use of unsuitable materials were cited as reasons for failure.

It was difficult to determine the scale of the problem nationally, because of lack of recent research comparing individual building sites containing buildings with and without preventive measures. One study in Northamptonshire suggested that 11% of homes built with preventive measures exceeded the radon Action Level, though data from Derbyshire suggested a much smaller problem there.

Suggestions for improving the success rate of preventive measures included:

- Better information and training for architects, builders, their suppliers, and the public
- More rigorous inspections during construction
- Routine testing of radon levels after construction

It is intended to hold another UK radon forum in 2006. Those wishing to be notified of the details should write to **radon@hpa-rp.org.uk.**

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Radon and PFA

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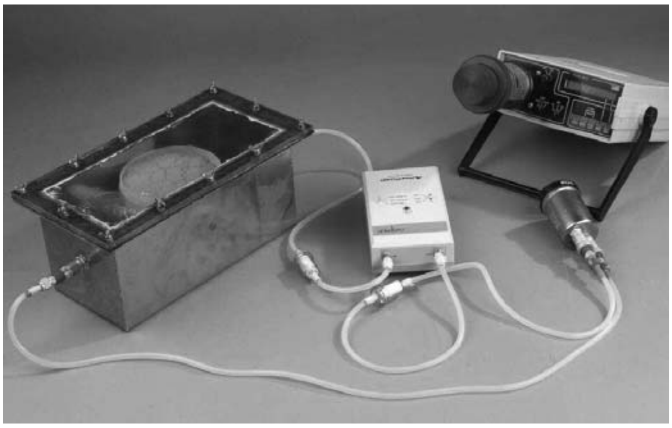
Although the main source of radon in a building is usually the ground, especially when radon levels are high, the materials from which it is built also make a contribution. In the UK, radon exhalation from building materials has not been a significant problem.

However, there have been notable exceptions in other countries, for instance from the lightweight concrete blocks made of alum shale in Sweden and similarly from the coal slags in Hungary, both of which contained high levels of radium. The radon exhalation from building materials is now covered by The EU Construction Products Directive (1988) which requires all building materials to be safe for their intended use and the *emission of dangerous radiation* to be within permitted levels.



PFA in radon exhalation box, with air pump and radon scintillation cell counter

Pulverised fuel ash (PFA), the residue from burning coal in power stations, has long been recycled to make lightweight blocks for the construction industry. In the UK, the promotion of the applications for PFA is carried out by the UK Quality Ash Association (UKQAA), which recently funded a study* to update the radiological information on PFA, given that most of the coal burnt in UK power stations is no longer from British deep mines. The study was carried out by the Health Protection Agency.

After assessing the concentrations of the naturally occurring radionuclides (uranium-238 and thorium-232 decay chains, and potassium-40) by gamma-spectrometry, samples of the PFA were placed in a special radon exhalation rig. Repeated measurements of the air from the rig showed how the radon concentration eventually reaches a plateau, where the amount exhaling from the surface of the sample is balanced by the radioactive decay of the radon gas. From the slope of the curve and knowing the size, shape and mass of the sample, a number of quantities could be calculated such as free exhalation and exhalation rate per unit area.

The results from the contemporary PFA samples were compared with those obtained in similar studies carried out previously, and from the open literature. The latest results were not significantly different from before, and within the usual range seen in European studies. Consequently, no change in the proportion of radon in UK buildings due to their construction materials is expected. Finally, it is unlikely that any of the trigger levels due to radioactive content or radon exhalation in current UK legislation and EU Directives will be exceeded.

* *A radiological study of pulverised fuel ash (PFA) from UK coal-fired power stations. T D Gooding, K R Smith, R A Carroll.* To be presented at AshTech, Birmingham, May 2006

How to measure radon – horses for courses!

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Paul Phillips, Anne Woolridge and Robin Crockett, University of Northampton
Gavin Gillmore, University of Bradford

Methods for measuring radon concentrations range from electronic systems, sampling continuously, to passive detectors exposed for three months. In selecting a method, the purpose of the measurement and the properties of radon must be considered, particularly where rapid results are required. To investigate the feasibility of estimating long-term average radon concentrations by short measurements, the University of Northampton Radon Research Group recently undertook an extensive study, funded by the Department of the Environment, Food and Rural Affairs*.

Detector assessment project

Thirty-four homes in and around Northampton were monitored using various detectors and exposure regimes. Seven-day measurements were made each month using co-located track-etch, activated charcoal and electret detectors, procured from participants in the NRPB intercomparison of passive radon detectors. Additional measurements were made using 1-month and 3-month track-etch detectors exposed sequentially for the project duration. Comparisons of dose-integrating detectors with continuously-monitoring systems demonstrated excellent sensitivity and linearity. The results confirmed that the variability observed in 7-day measurements reflects natural radon fluctuations rather than technology limitations.

Applicability

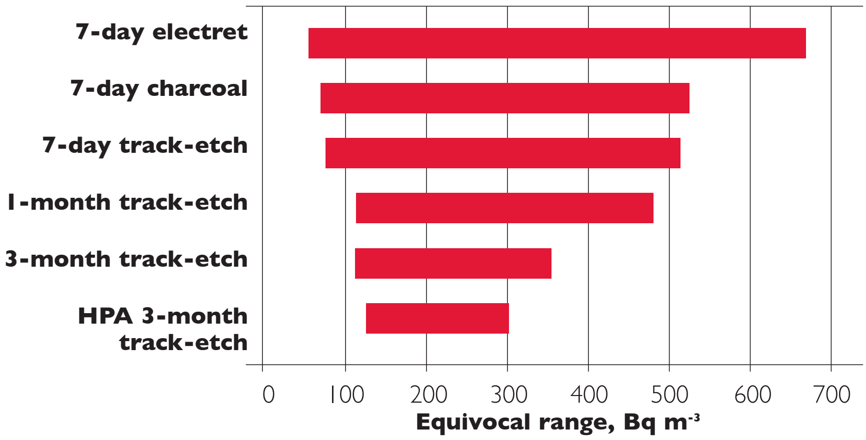
Activated charcoal detectors capture radon for later assessment, so the decay of radon constrains the measurement duration to a maximum of 7 days, and detectors must be processed within two days of completion of the exposure. They are suitable for short-term measurements only.

Electrets are suitable for short-term measurements. Since electronic equipment is required to measure start and finish voltages, this approach is unsuitable for householder use. Electrets can be re-used up to ten times under normal radon levels, offering a cost-effective solution for institutional users, e.g. Environmental Health Departments, Housing Associations or property developers.

Track-etch detectors configured specifically for short-term measurements are suitable for 7-day measurements, while devices configured for longer-term measurements are suitable for 1-month and 3-month use.

Equivocal Range

The extensive measurement series allowed us to assess whether a short-term result was truly indicative of the long-term average radon concentration relative to the Action Level of 200 Bq m^{-3} and, knowing the mathematical distributions of the results (which reflect the sensitivity and offset characteristics of individual detector types), to define an "Equivocal Range" for each detector. Results below the lower bound of this range confirm (95% confidence) that the mean annual radon concentration is below the Action Level; results greater than the upper bound confirm that the mean annual concentration exceeds the Action Level. Results falling within the Equivocal Range are inconclusive and should be repeated. Because of the temporal variability of radon levels in homes, more results will be found within the Equivocal Range for 7-day measurements than for longer measurements. Note that detectors provided by different suppliers could give different results from those shown.



Recommendations

Where time is not of the essence

- 3-month measurements using track-etch detectors are preferred for economy and ease of use.

For rapid determination of mean radon concentrations, preferred technologies are:

- Householder use: Activated charcoal or short-term track-etch
- Professional use: Electret

Measurement periods depend on the local radon environment:

- In areas with $\leq$ 5% of homes above the Action Level, 7-day measurements are appropriate for initial and repeat testing.
- In areas with $\geq$ 20% of homes above the Action Level, most 7-day results will be within the Equivocal Range; 3-month measurements are recommended for initial and repeat testing.

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Risks to children from radon

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Epidemiological studies of miners and of adults exposed in the home have demonstrated that elevated levels of radon are associated with increased risks of lung cancer. More detailed investigations show that the risk comes from the radon decay products rather than from radon gas itself. There is no such body of evidence to demonstrate that radon or its decay products present a risk to children, or the unborn child. Nevertheless, any exposure to radiation potentially carries some risk. We have carried out calculations* to investigate the magnitude of any such risk by comparing radiation doses to adults with those to children aged 1 and 10 years and to the fetus.

Inhaling air containing radon will lead to a radiation dose; if radon is dissolved in water there can also be a dose by ingestion. Normally inhalation is more important than ingestion. Radiation dose can be delivered both by radon gas and by its short-lived decay products. In the case of inhalation, the latter is more important, for ingestion it is the former. Radon decay products deposited on the skin may also irradiate the sensitive cells in which skin cancers originate.

The general pattern of doses to different tissues for inhalation and ingestion of radon and its decay products by children is similar to that in adults and annual doses are also broadly similar. Both for inhalation and for ingestion the organ of intake receives much higher doses than do other organs. In the case of inhalation the largest doses are to the lung and to the extra-thoracic part of the respiratory tract (the nose, pharynx and larynx). In the case of ingestion, the stomach receives a much higher dose than does any other organ.

Amongst other organs and tissues, those with a high fat content receive somewhat higher doses from radon gas. There is considerable public interest in childhood leukaemia. Red bone marrow, thought to be the tissue in which childhood leukaemias originate, does not receive doses which are large compared to other tissues. Nevertheless, the calculated doses are high enough to suggest that radon is responsible for a small proportion of childhood leukaemias.

It is possible that alpha particles from radon decay products can irradiate the cells in which skin cancers originate and thus induce skin cancer. However, the location of these sensitive cells is not known with certainty and it is possible that they lie too deep to receive significant dose. If they are irradiated, it is likely that the doses would be larger in the case of children than in adults. However, the evidence so far available is inconclusive.

We have also considered the dose to the fetus from intakes by the mother. The fetus has little fat until late in gestation, and there is no obvious biological mechanism for it to incur a dose very different from the dose to maternal muscle or other maternal organs which receive relatively low doses.

Children are generally thought to be somewhat more sensitive to radiation than adults. On the other hand, most epidemiological studies of lung cancer suggest an increased relative risk which falls in the thirty or forty years following exposure. Lung cancer is predominantly a disease of middle and old age. The natural lung cancer incidence in those exposed to radon in childhood would be very low during the following thirty or forty years, and the deleterious consequences may also be very low. The age distribution of many solid cancers follows that of lung cancer and broadly similar considerations apply equally to these.

Information is sparse, so it would be incautious to conclude that the radiological consequences of radon exposure in childhood were negligible. Current knowledge does not suggest that protection standards recommended for the population as a whole will not adequately cover children and the fetus. However, this is an area where further research would be useful.

** Doses from radon and decay products to children. G M Kendall and T J Smith, Journal of Radiological Protection 2005, 25 241-256.*

How to measure radon – horses for courses! *(continued from page 3)*

- In areas with 5% - 20% of homes above the Action Level, nearly 50% of 7-day results will be equivocal; 7-day measurements are of doubtful utility and 3-month measurements are recommended for repeat testing.
- 7-day measurements are suitable for newly-constructed houses with radon-mitigation precautions, where radon concentrations are expected to be low.

*Phillips, P.S., Denman, A.R., Crockett, R.G.M., Gillmore, G.K., Groves-Kirkby, C.J. and Woolridge, A.C. *Comparative Analysis of Weekly vs. three-Monthly Radon Measurements in Dwellings.* Defra Commissioned Research for Radioactive Substances Division. Report DEFRA/RAS/03.006. January 2004.

On-line at: **http://www.defra.gov.uk/environment/radioactivity/research/complete/pdf/defra_ras-03.006.pdf**

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This newsletter is prepared for the Chartered Institute of Environmental Health by the Radiation Protection Division, Health Protection Agency. It is published quarterly as an insert in Environmental Health, distributed by the Royal Environmental Health Institute for Scotland, and circulated to interested parties.

The views expressed in the contributions are not necessarily those of the Chartered Institute of Environmental Health, the Royal Environmental Health Institute for Scotland or the Radiation Protection Division, Health Protection Agency.