Environmental Radon Newsletter

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Remediation Case Study Series

6. Multiple internal sump and fan systems

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This is the sixth in a series of case studies demonstrating a range of practical and cost-effective radon reduction methods. Here is an example of a building with complex and diverse radon entry, requiring a number of active sump systems to be installed.

Measurement			Radon level (Bq m^{-3})	
Type	Duration (months)	Number of detectors	Lowest	Highest
Initial*	3	2	377	2459
Screening pre-remediation†	1	12	6	1610
Post-remediation*	3	12	5	64

* Occupational (winter-averaged) radon concentration
† No correction to winter average

RPW Radon Wales Ltd was instructed by the Hywel Dda Health Board, Carmarthenshire, to undertake a radon gas assessment process for over 200 hospitals, health centres and offices in west Wales. A pair of detectors (occasionally a few more) was placed for three months in buildings identified to be in or near to a radon Affected Area using the HPA/BGS indicative atlas (see *ERN* Issues 51 and 65). Radon measurements in one health centre had high levels (see the table), with one result over six times the UK occupational Action Level of 400 Bq m^{-3}.

The health centre is a single-storey bungalow, slightly larger than a typical three-bedroom bungalow, built in the 1970s with solid floors. Hywel Dda Health Board has its own Radiation Protection Adviser who, after the initial measurement report, identified remedial works would be necessary for the centre. Meetings were arranged with staff at the centre to discuss ventilation, health implications and exposure. One member of staff, who had worked at the site for over 25 years, and lived nearby, had a radon test carried out in her home. Although only a few hundred metres from her workplace, her home radon concentration was measured as low.

A series of one-month screening measurements was undertaken in all rooms of the centre to quickly identify the best location for remedial measures. The results showed several rooms with high radon levels.

RPW Radon Wales surveyed the property and designed and installed an active sump system. A series of five sumps and two fans was installed internally, with careful reinstatement as well as further sealant of the solid floor around the pipes, and connected through the loft-space to discharge at roof level. In collaboration with the estates management and with cost an important consideration, the site of the outlet was chosen as an end wall which had no nearby windows. Installation was completed during a weekend 'out of hours': there was no disruption to the health centre's usual operations.

Pipework being fitted into solid floor

Once installed, three-month post-remediation radon measurements were carried out to check the performance of the system (see the table). The results clearly identified that the bespoke remedial system (design and installation) worked extremely well, with the highest measured radon concentration in the building well below the Action Level.

The editor welcomes suggestions and contributions towards articles, particularly for the remediation case study series.

Richard Waters is a radon remediation specialist and has been a member of the Radon Council for six years. RPW Radon Wales (www.rpwradonwales.com) has worked with a number of organisations, government and local authorities in Wales including Hywel Dda Health Board, Carmarthenshire County Council, the Welsh Government, the MOD (RAF St Athan) and Wrexham University. The information in this article represents his judgements and views.

POINTS OF CONTACT

www.UKradon.org provides general information on radon and details of HPA radon services, including radon risk reports for individual properties in the UK

Radon Survey
Centre for Radiation, Chemical and Environmental Hazards
Health Protection Agency
Chilton, Didcot, Oxon OX11 0RQ
Tel: 01235 822622
email: radon@hpa.org.uk
www.hpa.org.uk/radon

BRE
Garston, Watford WD2 7JR
www.bre.co.uk/radon

Health and Safety Executive
Health Directorate B6
Rose Court, 2 Southwark Bridge
London SE1 9HF
Tel: 020 7717 6854
www.hse.gov.uk/radiation/ionising/radon.htm

Welsh Government
Department for the Environment, Sustainability and Housing
Cathays Park, Cardiff CF10 3NQ
Tel: 0300 060 3300

Industrial Pollution and Radiochemical Inspectorate
Northern Ireland Environment Agency
Gasworks Business Park, Belfast BT7 2JA
Tel: 028 9056 9299
email: IPRI@doeni.gov.uk
www.ni-environment.gov.uk/pollution-home/radiation/radon.htm

Scottish Government
Housing and Regeneration
Victoria Quay, Edinburgh EH6 6QQ
Tel: 0131 244 5575

Radon South West Committee
Secretary: Gerald Hudd
Malabar, Hillfarrance, Taunton
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Derbyshire Radon Steering Group
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Derbyshire Dales District Council
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Laboratories validated by the HPA for making measurements of radon concentrations in homes are listed at www.hpa.org.uk/radonvalidation

For a risk report where there is no valid postcode, the building footprint is larger than 25 m or for plots of land, visit shop.bgs.ac.uk/Georeports

Natural gamma radiation linked to childhood leukaemia

Jill Meara, Health Protection Agency, jill.meara@hpa.org.uk

A small, but statistically significant link between the risk of childhood leukaemia and natural levels of gamma radiation has been found by the Childhood Cancer Research Group (CCRG) of the University of Oxford, the US National Cancer Institute, the University of Manchester and the Health Protection Agency (HPA). The study is relevant to understanding the effects of low radiation doses from some forms of medical imaging.

The report that we have published in the journal *Leukemia** shows a statistically significant association between natural, low level gamma-ray exposure and childhood leukaemia, which we believe may be causal. If so, this would be one of the first demonstrations of radiation health effects in populations exposed to very low doses and dose rates of ionising radiation.

Gamma rays in background radiation come largely from naturally occurring radioisotopes of uranium, thorium and potassium in the environment, including the ground, buildings and food; there is also some medical exposure. In the UK, children have an annual radiation dose of roughly 0.7 millisievert (mSv) to bone marrow from natural gamma rays, or about 80 nanograys per hour (nGy h^{-1}), with a range of 70 to 120 nGy h^{-1} depending on location.

We used records from the UK National Registry of Childhood Tumours (NRCT) to investigate links with natural background radiation. A large record-based case–control epidemiological study was conducted to test associations between childhood cancer and natural background radiation. Cases (27,447), from the NRCT, born and diagnosed in Great Britain during 1980–2006 were matched with cancer-free controls as part of the study (36,793).

Nationally, the analysis showed a 12% increase in the risk of childhood leukaemia for every millisievert of cumulative natural gamma-ray dose to the bone marrow. Whilst this finding was statistically significant, there is still some uncertainty around the size of the effect. The relative risk increase is likely to lie within a range of 3% to 22% per millisievert. Associations for cancers other than leukaemia were not significant for either gamma-ray or radon exposure for typical natural background radiation.

The cause of most cases of childhood leukaemia is unknown. If we accept that the relationship is causal, background radiation would account for only a minority of cases. We estimated about 15% of the 500 or so cases of childhood leukaemia which occur annually in the UK may be due to natural background radiation. Natural gamma rays account for about half the dose reaching children's bone marrow from all sources, so they may account for approaching 40 childhood leukaemias a year. Almost all of the remaining exposure to the bone marrow is from natural radionuclides in food.

The statistically significant leukaemia risk is consistent with existing high dose rate risk models for ionising radiation, thus supporting their continued use. The results of the study do not support the hypothesis that there are no adverse effects of radiation, or that there are beneficial effects (hormesis), at these very low doses and dose rates.

While there is some variation in natural gamma-ray exposure around the UK, the gamma-radiation doses are small and there is little that can be done to mediate or prevent exposure. In this respect it is different to naturally occurring radon gas where radon exposure can be controlled.

* Kendall GM, Little MP, Wakeford R, Bunch KJ, Miles JCH, Vincent TJ, Meara JR and Murphy MFG (2012). A record-based case–control study of natural background radiation and the incidence of childhood leukaemia and other cancers in Great Britain during 1980–2006. *Leukemia* (5 June 2012), doi:10.1038/leu.2012.151

The study was funded by the Department of Health for England and Wales, the Scottish Government, and the charity CHILDREN with CANCER.

Factors affecting radon reduction

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The Health Protection Agency (HPA) has completed an extensive review of various radon reduction methods. The statistical analysis considered the effect of initial radon concentration, house characteristics and effectiveness of different types of contractor and those householders who DIY.

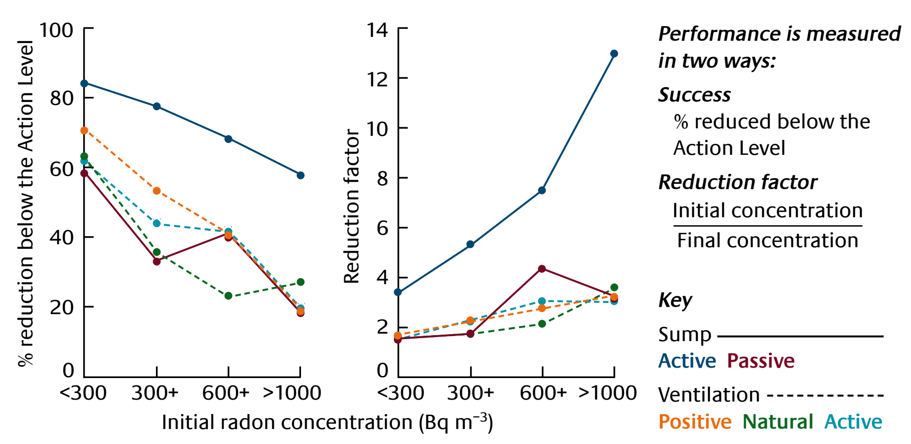
The HPA has an ongoing programme to 'find and fix' houses with radon concentrations at or above the Action Level (AL) of 200 Bq m^{-3}. The main aim of remedial work is to reduce radon levels to as low as reasonably achievable and to below the Target Level (TL) of 100 Bq m^{-3}. Householders with high radon levels receive free remedial advice from the HPA.

Information is routinely collected from householders who undertake remedial measures and have a radon test after remediation: this is stored in the UK national radon database. Analysis of the collected information has been carried out on around 2400 dwellings. The aims were to identify both the effectiveness of remedial measures and the factors that affect their performance, including the physical characteristics of the home, the radon level before remediation and who carried out the work.

To provide a reliable indicator of the effectiveness of the remedy, measurements over a three-month period were carried out before and after remediation. Multiple regression analysis (5% statistical significance level) was used to assess the relative effectiveness of different radon reduction measures and the influence of house characteristics.

An active sump is the most effective remedy, indicating a reduction factor of around six. Other techniques typically achieved reduction factors of around two; sealing floors and passive ventilation of living space are the least effective. Active measures generally perform better than passive measures.

Each remediation method showed a trend in performance with respect to the initial radon concentration – the higher the initial concentration, the better the reduction in exposure for most measures. Higher concentrations are less likely to be reduced below the AL. Even if the success rate of achieving a reduction below the AL is low, the reduction factor could be high and thus the remedy still achieves a significant reduction in exposure (see the figure).



Effect of initial concentration on reduction in radon level

The influence of each house characteristic on the performance of each remedial measure was also assessed. It was found that:

- Remediation performance is not significantly affected by the type of home or the heating method
- Double glazing generally improves remediation performance
- Sump systems are less effective in a house with a basement
- In single-storey homes, sumps and positive ventilation are more effective
- The more recent the build date, the more effective active sumps tend to be
- Performance of other measures is largely unaffected by the age of the home.

Remediation performance may depend on several factors: the initial radon level, house characteristics, choices made by the customer and who does the work (see the table). The best reductions are achieved by experienced contractors, then general contractors, followed by DIY. Further work is necessary to determine if better reduction factors are due to higher initial radon levels or the quality of work, or a mixture of both.

Improved guidance for householders, contractors and others will be prepared using information from this work. Guidance will be published as fact sheets on the dedicated HPA radon website (www.ukradon.org) so that householders can make better-informed decisions.

Effectiveness of remedial work by type of contractor

Initial radon concentration (Bq m^{-3})		Contractor EXP	GEN	DIY
<500	Number of homes	470	377	347
	Reduction factor	3.0	1.8	1.7
	% reduced below the Action Level	74.5	55.7	55.3
500–1000	Number of homes	205	115	65
	Reduction factor	5.4	3.1	2.9
	% reduced below the Action Level	61.5	38.3	38.5
>1000	Number of homes	109	55	32
	Reduction factor	8.5	9.2	5.3
	% reduced below the Action Level	45.0	49.1	40.6

EXP: experienced – those who have completed ten or more works
GEN: general – assumed to have less experience and not necessarily specialist radon contractors
DIY – householders doing their own work

This article is based on the report: Hodgson SA, Zhang W, Bradley EJ, Green BMR and McColl NP (2011), An Analysis of Radon Remediation Methods, Chilton, HPA-CRCE-019, available at www.hpa.org.uk. It was first presented in poster form at IRPA13 Glasgow, May 2012.

Awareness of radon in new-build homes

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A Health Protection Agency project targeting new-build homes in areas where radon is expected to be higher than the Action Level (200 Bq m^{-3}) in 10% or more of homes has begun. The aim is to investigate householder awareness of potentially high radon concentrations in their new-build homes and that they may have partial radon protective measures installed. Householders may not be fully aware of the implications of buying homes in these radon Affected Areas and that they should complete a radon test to check that radon concentrations are low after moving into the property.

In radon Affected Areas of England and Wales, where the percentage of homes at or above the Action Level exceeds 3%, guidance advocates the inclusion of 'basic' radon protection in new buildings*. Basic radon protection consists of a well-installed damp-proof membrane, modified and extended to form a radon-proof barrier across the ground floor of the building.

This project targets new-build homes in England where the radon potential is higher, with more than 10% of homes predicted to be above the Action Level. Guidance related to building regulations advises that new buildings in such areas should include provision for 'full' measures. Full protection provision generally consists of basic measures plus either a capped 'standby' radon sump or a ventilated sub-floor void (see the figures). The result of a post-occupation radon measurement should be used to decide whether the full measures should be activated by adding a fan to the sump system or to the under-floor space. In many cases, it is expected that radon levels will not warrant the completion and activation of the full measures. Similar guidance applies for Scotland and Northern Ireland.

Figure 1 Capped standby sump installed during house construction © BRE

* Scivyer C (2007). Radon Guidance on Protective Measures for New Buildings, BR 211. BRE, Watford.

Figure 2 Under-floor ventilation installed in sub-floor void during house construction © Jane Bradley

The policy intends that such homes have basic protection 'built-in', but it is recognised that, in these higher probability areas, this generally offers only partial protection: all homes in these areas should be measured for radon once occupied. After measurement, an informed decision can be made by the householder/landlord about completing and activating the full measures. There is presently little information available on the level of knowledge in this group of householders about these factors.

This project will use a targeted approach to gauge householder or landlord knowledge through a suitable questionnaire and offer a free radon test. This will help householders decide whether to activate the full measures. The first phase of the project targets homes built in 2010 in England. It will deliver:

- Health protection outcomes to householders in the form of improved knowledge on:
  - the radon potential at their location
  - the radon level in their home
  - methods of reducing radon where levels are high
- Opportunities for improving protection against radon in the form of evidence:
  - to inform change, if needed, to questions on conveyance documents
  - to develop recommendations for improving householder knowledge in new homes in relevant areas
  - to encourage testing and remediation by householders.

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