



# Radon

► **Odourless, colourless, tasteless**, naturally occurring radon gas seeps through the ground, becoming trapped in buildings. Continuous exposure to high levels of radon carries significant health risks, as **Rebecca Kench** reports.

**R**adon is a natural radioactive gas which accounts for around fifty percent of the radiation each person in the UK is exposed to each year. The gas occurs when uranium in soil and rocks decays. This gas then permeates through the ground into buildings or the open air. You can't see or taste radon but we all breathe it in throughout our lives.

Small amounts of radon are present in buildings of all types, ages and locations, both domestic and business premises. In the

open air the gas is quickly diluted to low concentrations, however, when it permeates into a building it can become trapped and radon levels can increase to dangerous concentrations.

When concentration of the gas is high, the radioactive decay products from the gas (called radon daughters) can be inhaled and deposited in the lungs where they can continue to emit radiation. Health studies from around the world link exposure to high levels of radon with an increased risk of lung cancer. In fact, exposure to radon is second only to

smoking as a cause of lung cancer in the UK. Smokers exposed to high levels of radon are at an increased risk of developing lung cancer, with some studies suggesting that they are 25 times more likely to develop lung cancer than non-smokers exposed to high levels of radon.

Buildings in certain areas of the UK are more likely to contain high levels of radon, due to the underlying geology and varying amounts of uranium present in the soil.

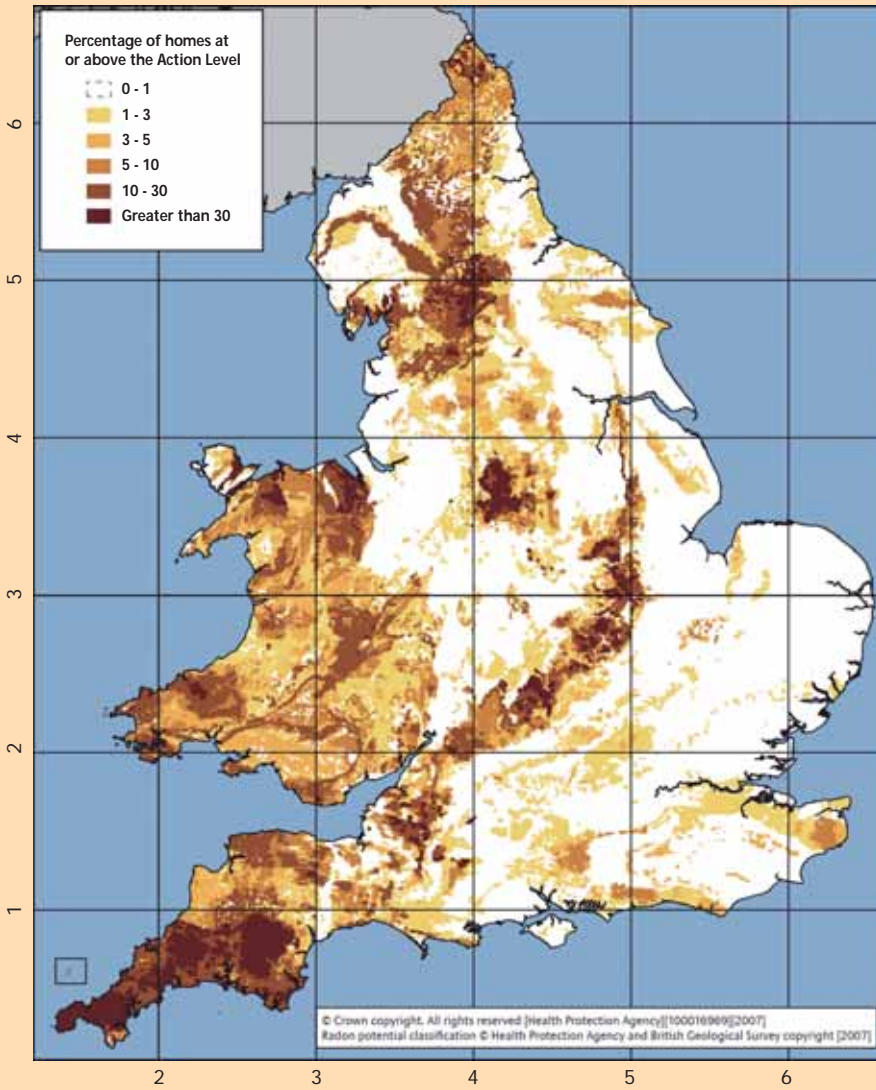
The latest set of radon maps published by the Health Protection Agency (HPA) show that these areas include large parts of the South West, Northern England, the Midlands, the South Coast and the whole of Wales. Areas such as these, where it has been estimated that more than one percent of properties will contain high levels of radon, are classed as radon Affected Areas (see map on page 24). ►

“Health studies from around the world link exposure to radon and an increased risk of lung cancer.”





**Overall map of radon Affected Areas in England and Wales**  
(axis numbers are the 100km coordinates of the national grid)



an adequate barrier to water penetration.

The main factor responsible for radon gas entering a property, however, is advection. This is the movement of the gas from the soil to the lowest point of pressure, which is usually inside the building. This means that the gas is literally being sucked from the ground into the building and the greater this pressure difference is, the faster the rate at which the gas is drawn inside is.

## Testing

Radon is odourless, colourless and tasteless, so the only way to know it is there, and to assess the level of it, is to conduct a specific test for it.

Employers with premises that contain basement workspaces or that are situated in Affected Areas have a legal duty to conduct a radon test. Under the *Management of Health and Safety at Work Regulations 1999*, employers must assess all risk to their workforce, and risk of high levels of radon being found in a building situated in an Affected Area or with a basement is significant, so a test must be conducted. Testing for radon is the only way to know whether employees' health is at risk from the gas.

The Health and Safety Executive (HSE) can enforce radon testing in commercial properties and has a team of radiation inspectors who visit workplaces to ensure that a radon risk assessment has been completed. Enforcement duties for some sectors have been delegated to local authority environmental health officers.

To assess the level of radon in an existing building, a specialist detector must be placed in the property before being sent to a laboratory for analysis. Radon detectors are small and discreet, and the whole process including laboratory analysis is inexpensive. As radon levels fluctuate according to seasonal variances (eg. levels are higher in winter, a reason for this is the added amount of ventilation in a building (through open windows) in the warmer months) a three month testing period is required to take such inconsistencies into account.

There are set maximum levels that radon concentration should not exceed inside

“... the gas is literally being sucked from the ground into the building.”



But even buildings not in Affected Areas can be susceptible to high levels of radon. The HPA recently advised that any property with a basement, regardless of whether it is located in an Affected Area or not, will have an increased probability of containing high radon concentrations. This is because buildings with basements or underground levels have a larger surface area in contact with the soil through which radon gas can permeate.

## Entry

Mostly, radon will passively infiltrate into a building, for example, through cracks in the foundations and gaps around service pipes. Evidence has also been found to demonstrate that radon can pass through certain building materials, even those which provide



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buildings. These Action Levels are the point at which it is advised (or required, in the case of workplaces) that action is taken to lower the concentration. In domestic properties, the level is set at 200bq/m<sup>3</sup> (this may be lowered to 100bq/m<sup>3</sup>) and in commercial properties the Action Level is 400bq/m<sup>3</sup>. (Note: The average background radon concentration in the open air is 4bq/m<sup>3</sup> and the average radon level inside buildings is 20bq/m<sup>3</sup>.)

For most employers, radon levels on their premises will be below 400bq/m<sup>3</sup> so no further action will need to be taken after testing has been carried out. However, the risk assessment for radon should still be regularly reviewed. HSE suggests the following guidelines for

deciding when to carry out a review:

- where radon levels were found to be significantly less than 400bq/m<sup>3</sup> at the initial measurement, the period of re-measurement might be of the order of once every 10 years
- where radon levels were just below 400bq/m<sup>3</sup> at the initial measurement, the suggested period for re-measurement will be less than 10 years

If a workplace premises is found to contain levels of radon in excess of the Action Level of 400bq/m<sup>3</sup>, control methods must be put in place to reduce the concentration, otherwise the employer will be in breach of the *Ionising Radiations Regulations 1999* (IRR99). These regulations apply to workplaces where radioactive substances and electrical equipment emitting ionising radiation are used. IRR99 (see: [www.opsi.gov.uk/si/si1999/19993232.htm](http://www.opsi.gov.uk/si/si1999/19993232.htm)) also apply to work in which people are exposed to high levels of radon gas and therefore its decay products.

The regulations require employers to keep exposure to radon below 400bq/m<sup>3</sup> by introducing, if necessary, control measures. As the air pressure inside a building is the main



➤ Wall-mounted radon detector

factor affecting the entry of radon gas, techniques which alter this pressure differential are the most successful ways of remediating buildings with high radon levels. Two such techniques are the use of specialist positive pressure units and retro-fitting a radon sump beneath the building. PPE should only be used to prevent exposure to radon as a last resort.

- Positive pressure units are commonly used to deal with condensation. They draw air into the building at a greater rate than it naturally escapes, raising the pressure inside the building and therefore forcing moist air out through a building's weak points.

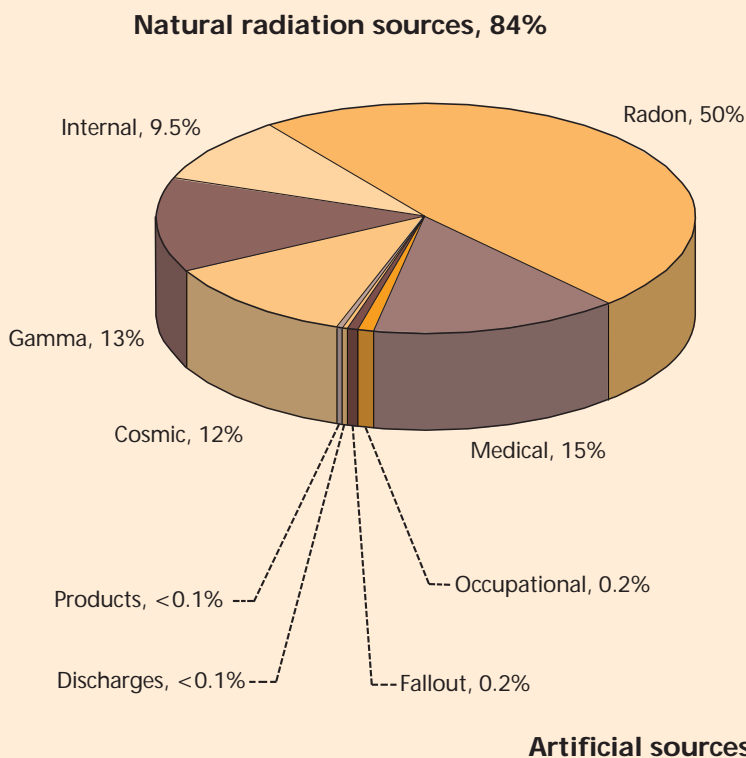
When calibrated for radon remediation, these units can raise the pressure inside the building to a level just higher than the pressure in the ground. This creates a 'pressure buffer' across the floor (and other earth-retaining surfaces) of the building to halt the process of advection.

Positive pressure units have been subject to significant technological advances over recent years and have been successfully used to remediate buildings with radon levels in excess of 10,000bq/m<sup>3</sup>. They are inexpensive to run (about the same cost as a light bulb), quiet and do not create a draught.

- A radon sump is a void created beneath a building by excavating a small amount of material from the ground. Radon gas in the soil is then drawn to this area because the sump makes the area the lowest point of pressure.

An extract pipe can be attached to the void to dispel the gas from the sump to a safe location (usually above eave level) and prevent it from permeating the building. ➤

## Average annual dose of ionising radiation to the UK population from all sources (total 2.7mSv)



Source: HPA



# Health Matters



➤ Examples of positive pressure units installed by specialist contractors

## Case studies

- Following a visit from an HSE inspector, a college carried out radon tests and found high levels of radon throughout the building. In many classrooms, radon levels over 800 $\text{Bq}/\text{m}^3$  were found, and in three offices which backed onto an earth-retaining wall, levels between 6,000 and 10,500 $\text{Bq}/\text{m}^3$  were found.

Work to reduce radon levels needed to be carried out quickly to avoid the college being forced to close, and so a specialist firm was contracted to remediate the building. Three large positive pressure units were installed in the roof void, along with a network of pipes and vents into individual rooms. Rooms that were inaccessible from the roof void had individual 'through the wall' positive pressure units installed, which are small and discreet.

Unused voids beneath the building were discovered, which are now being used as a sump system, with inline fans directing the gas collected here out of the building through pipes.

The level of radon throughout the majority of the classrooms and offices has now fallen below 400 $\text{Bq}/\text{m}^3$ . However, in one particular area of the building where 6,600 $\text{Bq}/\text{m}^3$  was initially found, the level has dropped only to around 2,000 $\text{Bq}/\text{m}^3$ . Further sump systems will be installed in this area, and the radon level will be continually monitored until levels have been reduced sufficiently.

This case highlights the importance of using a specialist contractor with the skills and expertise necessary to manage a radon problem, not simply install a system and leave site, hoping for the best.

- A luxury hotel company carried out radon tests throughout its buildings, and found high concentrations in certain areas. In particular, the large commercial kitchen, which was located on a lower ground floor level and had earth-retaining walls, was found to contain over 6,000 $\text{Bq}/\text{m}^3$ .

12 members of kitchen staff regularly worked 10 hour shifts in this part of the building, meaning that for every shift worked, each member of staff received the equivalent radiation dose of undergoing approximately 10 chest X-rays.

A specialist contractor installed several large positive pressure units at various locations in the building, along with a network of pipes and vents into individual rooms. Rooms that could not be connected to the large positive pressure units had individual units installed.

Radon tests were carried out shortly after the works had been completed, and showed that the control measures installed had successfully lowered the radon level to less than 150 $\text{Bq}/\text{m}^3$  throughout the whole building.

It should be recognised that radon mitigation is a specialist service, where an understanding of the science behind radon movement is required. Choosing the wrong solution to reduce radon levels can in fact exacerbate the problem. For example, some techniques, such as the use of extraction fans to increase ventilation can cause greater volumes of the gas to be drawn into the building.

Even with many years' experience in dealing with radon mitigation, a specialist contractor may not always solve the problem at the first attempt – no two buildings are identical, neither is the geology beneath any two plots of land. Where very high levels of radon have been found in a building, it may take several attempts and various combinations of techniques to sufficiently lower the concentration of the gas.

After any radon remediation work has been carried out, it is imperative that another radon test is done to determine whether it has been effective. Given the nature of radon entry into buildings, radon should be viewed as something that needs to be continually managed.

## Advice for employers

- [www.ukradon.org](http://www.ukradon.org)
- [www.radoncouncil.org](http://www.radoncouncil.org)
- [www.bre.co.uk/radon](http://www.bre.co.uk/radon)
- [www.hpa.org.uk](http://www.hpa.org.uk)
- [www.hse.gov.uk/radiation/ionising/radon.htm](http://www.hse.gov.uk/radiation/ionising/radon.htm)

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