Understanding Radon Remediation

A Householder's Guide

Radiological Protection Institute of Ireland
An Institiúid Éireannach um Chosaint Raideolaíoch

Contents

This guide is produced for information purposes only. Householders with specific questions should consult an architect, engineer or radon remediation specialist.

Introduction

This Guide has been prepared by the Radiological Protection Institute of Ireland (RPII) and is directed at householders who have been informed they have radon concentrations above the Reference Level in their home. The aim of the Guide is to assist such householders in interpreting their radon measurement results and in deciding how to deal with the problem.

Having received the result of a radon test the important point to note is that radon is not a problem one has to live with. There is a range of effective and relatively inexpensive remediation techniques available for reducing indoor radon concentrations. There is nothing complex about these techniques and the majority involve relatively simple building work. While some of the work described can be successfully undertaken by DIY enthusiasts or small builders, for more complex situations or where a significant reduction in radon concentration is required, it may be necessary to consult a contractor specialising in radon remediation.

This guide provides basic information on radon remediation methods so as to enable householders to decide what to do next. It does not provide detailed technical instructions for radon remediation but aims to give householders a general understanding of the methods available. Householders who wish to do the work themselves or who require more information should refer to "Radon in Existing Buildings – Corrective Options" published by the Department of the Environment, Heritage and Local Government. This report is available from the Government Publications Sale Office (Tel. 01-6793515) or the Department's website at **www.environ.ie.**

Radon can be measured using detectors such as shown above.

What is Radon?

Radon is a naturally occurring radioactive gas. It originates from the decay of uranium, which is present in small quantities in all rocks and soils. It is colourless, odourless and tasteless and can only be measured using special equipment. Because it is a gas, radon can move freely through the soil enabling it to enter the atmosphere. When radon surfaces in the open air, it is quickly diluted to harmless concentrations, but when it enters an enclosed space, such as a house, it can sometimes accumulate to unacceptably high concentrations.

Radon can enter a building from the ground through small cracks in floors and through gaps around pipes or cables. Radon tends to be sucked from the ground into a building because the indoor air pressure is usually slightly lower than outdoors. This pressure difference occurs because warm indoor air is less dense than outdoor air.

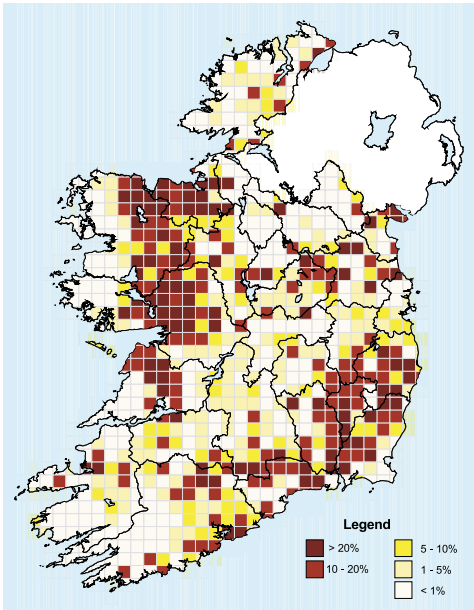
Radon decays to form tiny radioactive particles, some of which remain suspended in the air. When inhaled into the lungs these particles are deposited in the airways and attach themselves to lung tissue. They may damage cells in the lung and this damage may lead to lung cancer in later life. Radon is classified as a Group 1 carcinogen by the International Agency for Research on Cancer, a part of the World Health Organisation. This means that there is direct evidence from human studies to support the link between exposure to radon and the induction of lung cancer. It should be noted that exposure to radon has not been linked with any other health effects.

Radon in Ireland

Radon concentration is measured in becquerels per cubic metre of air (Bq/m^3). The becquerel is a unit of radioactivity and corresponds to one radioactive disintegration per second. In 1990, the Government adopted a long-term averaged radon gas concentration of 200 Bq/m^3 as the national Reference Level for radon in homes.

The radon concentrations measured in individual Irish homes range from a few tens of Bq/m^3 to several thousand Bq/m^3. The average concentration measured during the National Radon Survey is 89 Bq/m^3. On the basis of this survey it is estimated that 7% of all Irish homes have radon concentrations above the Reference Level. The results of the survey enabled the RPII to designate parts of the country as High Radon Areas. High Radon Areas are defined as 10 x 10 km National Grid squares in which the predicted percentage of homes with radon concentrations above 200 Bq/m^3 is 10% or greater.

High Radon Areas are found in all counties. Details of the National Radon Survey, as well as county maps showing the distribution of indoor radon concentrations, can be found on the RPII website **www.rpii.ie.**



Prediction map of Radon in Irish dwellings.

What Does My Radon Measurement Result Mean?

The RPII advises that, if the radon concentration in your home is above the national Reference Level of 200 Bq/m^3, you should consider taking remedial action to reduce it. The Reference Level does not represent a rigid boundary between safe and unsafe radon concentrations but rather a level at which it is prudent to consider remediation.

Lifetime exposure in the home to radon at the Reference Level represents a level of risk similar to several other everyday risks such as fatal accidents on the road or death due to accidental falls. Using international risk estimates the RPII has calculated that some 150 to 200 lung cancer deaths every year in Ireland are due to radon. Table 1 compares the estimates of risks from radon with the number of deaths from other causes in Ireland in 2003.

Exposure over your lifetime to a radon concentration of 200 Bq/m^3 represents a lifetime risk of contracting lung cancer of 1 in 50 i.e. 2%. Each additional 100 Bq/m^3 represents a further 1% lifetime risk. These risks are for the general population and are therefore averaged over smokers and non-smokers. Smokers are already at a significant risk of contracting lung cancer and exposure to radon will further increase that risk.

Table 1
Deaths in Ireland by Cause (2003)

Cause of death	Actual Deaths[1]	% of Total
All causes	28,823	100
Heart Disease	5,648	20
Lung Cancer	1,587	6
Suicide	444	1.5
Traffic Accidents	293	1.0
Accidental Falls	333	1.2
Workplace Accidents	67	0.2
Meningitis	17	0.06
	Estimated Deaths[2]	
Radon (89 Bq/m^3)	150-200	

[1] Data provided by the Central Statistics Office and Health and Safety Authority
[2] Calculated by RPII based on international risk estimates.

For any individual, the risk of lung cancer from smoking depends on a number of factors. When all these factors are averaged out, the lung cancer risk from radon for smokers is about twice the value for the general population while the risk for non-smokers is lower by approximately a factor of five.

The risk from radon depends on the total radon exposure received over the course of a lifetime. Radon, therefore, does not pose an immediate risk but is something that should be controlled over the longer term. In the case of children, if radon exposure starts at a young age, the total number of years of exposure is potentially greater and therefore a precautionary approach to the exposure of children to high radon concentrations is recommended.

Remediation should be undertaken as soon as practicable and at higher concentrations a greater urgency is recommended.

Radon concentration is determined by analysing the detectors under a microscope.

Radon Remediation Techniques

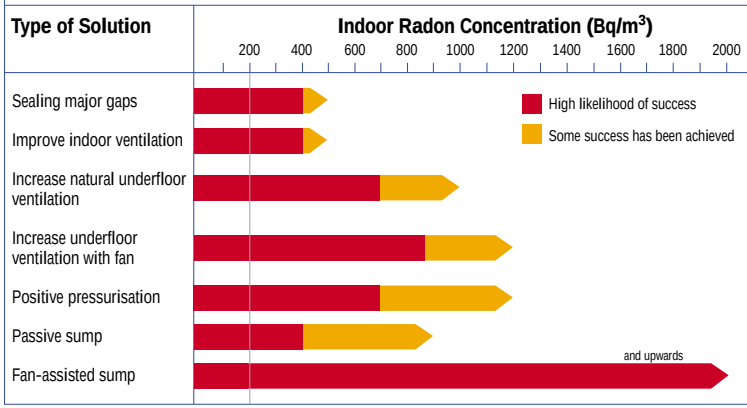
In recent years a considerable body of experience has been built up on effective and relatively inexpensive remedial techniques for reducing indoor radon concentrations. Radon remediation works either by preventing the entry of radon into a building from the soil or by removing it after it has entered by means of improved indoor ventilation. The most common remediation techniques include: sub-floor depressurisation (radon sump), increased under-floor ventilation, positive pressurisation, increased indoor ventilation and the sealing of cracks and gaps in the floor and around service entry points.

The most appropriate remediation solution for a particular building will depend on a number of factors including the measured radon gas concentration and the type of building. Through the correct choice of remediation technique it is possible to reduce the radon concentration well below the Reference Level in the vast majority of buildings. Figure 1 shows the range of radon concentrations over which some common remediation techniques are likely to be effective.

It can be seen that at radon concentrations of 300 Bq/m^3 any type of remediation is likely to be effective in reducing radon concentrations to below the Reference Level. For concentrations up to about 800 Bq/m^3, while there are a number of different remediation options that might succeed, the installation of an active sump or an increase in under-floor ventilation are the options most likely to be successful. For radon concentrations greater than about 1000 Bq/m^3 installation of an active sump is always the preferred remediation option.

Some householders opt to undertake radon remediation on a phased basis. This means that the simplest, least expensive solution, which offers reasonable potential for achieving the desired reduction, is undertaken first. Following this the house is retested and, if the radon concentrations have not been lowered sufficiently, then other measures are installed progressively until the required radon reduction is achieved. Alternatively, more extensive and therefore more expensive radon remedial measures may be undertaken to begin with in order to ensure that the radon concentrations will be reduced sufficiently on the first attempt. The phased approach is more likely to be adopted where the householder undertakes the work on a DIY basis, while specialist contractors will usually take the latter approach.

Figure 1
Guide to the Likely Effectiveness of Remediation Techniques*



* reproduced with permission of UK Building Research Establishment

An overview of the most commonly used remediation systems is presented here. Technical guidance on these techniques and their installation is given in the booklet "Radon in Existing Buildings - Corrective Options" referred to earlier.

Sealing Floors and Walls

In theory it is possible to prevent radon from entering a house from the ground by sealing all radon entry points such as cracks in solid floors, cracks or openings in ground contact walls and gaps around cables or pipes. In practice, however, effective sealing is often extremely difficult to achieve.

Sealing all possible entry routes involves removing floor covering and skirting boards and then sealing all cracks and joints with a suitable sealant. The sealant must be durable and flexible enough to accommodate future movement of building materials.

For this method to be successful, effectively all gaps have to be sealed. This is difficult since some gaps may not be visible and over time new cracks and openings may develop. If only 90% of openings were sealed, for example, then radon could enter through the remaining gaps and it is likely that only a slight reduction would be achieved. In practice this method is more likely to be used in conjunction with other methods than on its own.

Increasing Indoor Ventilation

It may be possible to increase the ventilation in a house by unblocking air vents, providing additional wall vents or by installing window trickle vents. Increasing the ventilation mixes radon-rich indoor air with outdoor air thereby bringing down the radon concentration in indoor air. Increased ventilation also reduces the under-pressure in a house and so reduces the tendency for radon to be sucked into the house from the ground.

Increased background ventilation should only be installed at ground floor level as increasing the ventilation in upper floors may result in higher radon concentrations. This is because increased ventilation on upper floors may cause a stack effect, which draws air up through the house.

This remediation solution has the advantage of being fully passive and so does not require long-term maintenance. It may also help to improve indoor air quality generally.

Increasing Under-floor Ventilation

Increasing the flow of air beneath the floor can reduce the amount of radon entering the building. This involves the installation of additional sub-floor vents or airbricks or the clearing or replacement of existing ones. Plastic airbricks are now available with a larger open surface than clay airbricks of the same size. The position of the airbricks can have a significant influence on the radon reduction achieved, as dead spaces with no flow of air will reduce their effectiveness.

If it is found that the desired reduction in radon concentration has not been achieved, installing a fan can increase under-floor ventilation further. Fans can be installed to blow air into the underground space (supply ventilation) or suck air from underground space (extract ventilation).

Positive Pressurisation

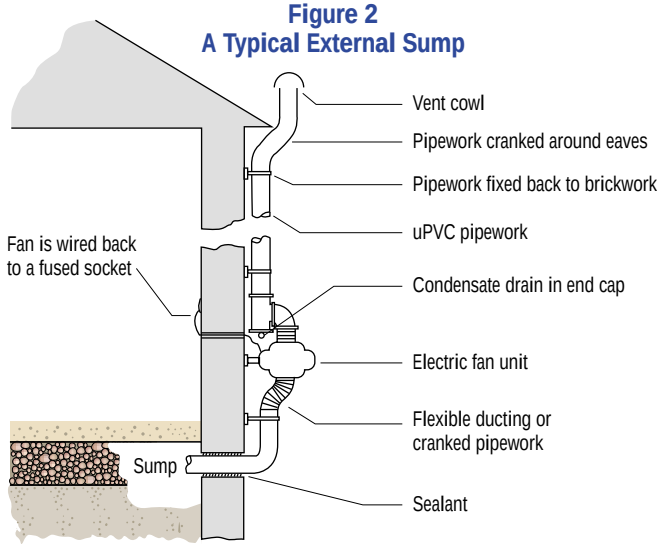
This method of radon remediation involves blowing air into the house from a specially installed fan unit in the attic, thus achieving a very slight positive pressure in relation to outside air. This reduces radon entry due to a pressure effect causing air to be forced out through cracks, joints, windows and openings. Positive pressurisation also has the effect of increasing ventilation and thereby reducing the radon concentration by dilution.

Positive pressurisation is best achieved in relatively airtight houses. Many existing houses may be relatively draughty and measures to reduce draughts may be needed to ensure effective pressurisation. It is straightforward to install, requires no major structural intrusion and has the added advantage of reducing condensation problems. However the running costs of such a system are likely to be greater than for an active sump.

The Radon Sump (Sub-floor Depressurisation)

A radon sump comprises a cavity about the size of a bucket in the ground immediately under the floor slab that is open to the surrounding under-floor hardcore and linked by pipe work to the outside. It operates by reversing the pressure differential between the space under the floor and the room above. The radon-laden air coming from the ground is drawn out from under the slab by an electric fan in the pipeline and so is prevented from entering the occupied indoor space (see Figure 2). Using a sump with a fan in this way is known as an active sump.

Figure 2
A Typical External Sump



Where a fan is not used the arrangement is referred to as a passive sump. A passive sump has the advantage of having no operating costs and being absolutely silent. However, it is less reliable than an active sump and probably would only be appropriate for radon concentrations up to a few hundred Bq/m^3. Where radon concentrations of several hundred Bq/m^3 or higher are present, the active sump is likely to be the most effective solution. A passive system, if not successful, can be upgraded to an active system by addition of a fan.

The number of sumps needed depends on the layout of the building, the floor area and the initial radon concentrations present. As a general rule, a single sump is effective over a surface area of 250 square metres. Several sumps can be linked together and served by the one fan.

The RPII recommends that, following remediation, all homes should be retested in order to verify that the radon concentrations have been reduced sufficiently. This measurement should be for a minimum of three months duration.

The 1997 Building Regulations

The 1997 Building Regulations specify that all new houses built since 1st July 1998 must be fitted with an inactive radon sump. The sump can be activated at a later stage to reduce radon concentrations if this is found to be necessary. For houses built in High Radon Areas the installation of a radon barrier as well as a sump is required.

The installation of these remedial measures is not a guarantee that radon concentrations will be below the Reference Level. You should therefore have a radon measurement made within the first year of moving into your new home. Should elevated radon concentrations be present, the sump can be activated by extending the pipe work and adding a fan. This greatly reduces the cost and disruption associated with remediation as the need to excavate beneath the existing house in order to install a sump is avoided.

Specific guidance on radon remediation measures for new buildings is contained in the 2004 edition of "Technical Guidance Document C - site preparation and resistance to moisture"[3] (TGD-C).

[3] Documents known as "Technical Guidance Documents" are published by the Department of the Environment, Heritage and Local Government for the purpose of providing technical guidance on the application of the Building Regulations. They can be found at **www.environ.ie** or can be ordered from the Government Publication Sales Office, Tel: (01) 679 3515.

Seeking Advice

For general information on radon, its health effects and radon measurements contact the RPII on Freefone 1 800 300 600. Full information, including a list of radon remediation companies, can be found on the RPII website **www.rpii.ie.**

For further information on the technical aspects of remediation options, contact the building control officer in your Local Authority or the Building Standards section in the Department of the Environment, Heritage and Local Government on 01 888 2000.

Further Reading

www.rpii.ie/radon

Radon in Existing Buildings - Corrective Options. Department of the Environment and Local Government, 2002.

Radon in Dwellings - The Irish National Radon Survey. RPII 02/1, 2002.

Technical Guidance Document C - Site preparation and resistance to moisture (TGD-C). Department of the Environment and Local Government, 2004.

Surveying dwellings with high indoor radon levels: a BRE guide to radon remedial measures in existing dwellings. Building Research Establishment Report Ref BR250, 1993.

Protecting dwellings with suspended timber floors: a BRE guide to radon remedial measures in existing dwellings. Building Research Establishment Report Ref BR239, 1993.

Sealing cracks in solid floor: a BRE guide to radon remedial measures in existing dwellings. Building Research Establishment Report Ref BR270, 1994.

Radon sumps: a BRE guide to radon remedial measures in existing dwellings. Building Research Establishment Report Ref BR227, 1992.

Notes

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