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Rebecca Kench of specialist contractor ProTen Services Ltd explains the dangers of radon gas and recommends the 'best practice' for installing radon protection in new buildings.

Radon: risk and regulations

Radon is a naturally occurring radioactive gas, formed during the decay of uranium in the ground. When it surfaces into the open air it is quickly diluted to a harmless concentration, however if it enters a building, it can become trapped and potentially dangerous levels can accumulate. Statistics reveal there are approximately 2500 deaths in the UK every year from lung cancer, linked directly to long-term exposure to high concentrations of radon.

Radon is found in all parts of the UK, but buildings in certain areas are more likely to contain high levels of the gas than others, due to the underlying geology. Areas where the British Geological Survey (BGS) and the Health Protection Agency (HPA) have estimated that more than 1% of homes will contain elevated levels of radon are known as Affected Areas.

Many people mistakenly believe that radon only affects the South West of England and granite-rich areas, however there are many other areas of the UK classified as Affected Areas. For example, in Northamptonshire, built largely on sand, it has been estimated that more than 30% of homes contain high levels of radon. The Peak District, built mainly on limestone has also been estimated to contain a similar proportion of properties affected by the gas. Affected Area status is based upon sample testing and data extrapolation, and is therefore only a prediction. Not all properties located in an Affected Area will contain high levels of the gas, and similarly, properties that are not located in an Affected Area could still be

harbouring high radon concentrations.

This is especially relevant if a property has a basement or cellar. As radon enters a building through the ground, a property with earth-retaining walls has a higher surface area through which the gas can permeate, and therefore an increased likelihood of containing high radon levels. The HPA has recently advised that 'high radon levels can be found in basements anywhere in the country, regardless of Affected Area status' (Tracy Gooding, HPA, Environmental Radon Newsletter, Winter 2007).

'If in doubt, don't build without'

Protection can be installed at the time of construction that should prevent the gas from infiltrating into the property. Measures can also be taken to provide a 'back-up' remedial solution that can be activated, if the building later develops a radon problem.

Section C1 [Resistance to Contaminants] of Schedule 1 of the Building Regulations 2000 states that 'Reasonable precautions shall be taken to avoid danger to health and safety caused by contaminants on or in the ground covered, or to be covered, by the building and any land associated with the building'.

Further guidance is given in Approved Document C (2004 edition), where section 2.39 explains that 'To reduce the risk [to occupants of developing lung cancer] all new buildings, extensions and conversions, whether residential or non-domestic, built in areas where there may be elevated radon emissions, may need to

incorporate precautions against radon'. Section 2.40 continues to inform that guidance on the areas susceptible to radon can be found in BRE Report 211 (revised 2007).

These Regulations leave themselves open to individual interpretation, and unfortunately do not appear to provide a definitive ruling as to whether a new building in any given area must have radon protection installed. Given the potentially serious consequences to occupants of a building that is not protected from radon, however, it is advisable that all specifiers and developers err on the side of caution.

Although BRE Report 211 was revised in 2007, a printed map has limitations as to the level of detail that can be provided for a given area. The HPA and the BGS have recently launched a website, (www.ukradon.org), which allows visitors, for a small fee, to input a postcode to obtain an estimate of the radon level for a specific property or piece of land. The website is constantly updated to give visitors the most up-to-date and accurate information, which may not be the case from a printed map. However a property could be affected by radon even when the maps and dataset indicate otherwise, and the postcode search does not take into account whether the property contains a basement.

Some areas shown as Affected Areas in the HPA maps are not shown as requiring any form of radon protection in BRE 211. ProTen Services advise that any development in a location designated as an Affected Area by the HPA should include at least a radon barrier (classi-

Fig 1. Radon membrane laid across the entire building footprint

fied as 'basic protection' by BRE 211). The mantra 'to test is best' is often applied with regards to radon in existing buildings, however for radon protection in new buildings, the best advice is 'if in doubt, don't build without'.

Methods of protection

A radon membrane laid across the footprint of a building provides basic protection from the gas. This combines as a damp proof membrane and vapour barrier and the cost difference between this and a basic DPM is negligible; the additional cost for most buildings will be marginal.

As far as practicable, membrane joints should be heat welded (using hot air), rather than taped, to minimise the risk of leakage. Most tape materials have not been certified as being gasproof, so even if the joint is completely sealed, radon could still permeate the tape itself. Pre-formed collars or 'top-hats' should be used around service inlets.

BRE 211 also refers to 'full' protection. In addition to installing a radon membrane, this involves creating a remedial system that can be commissioned at a later date, if the property is found to contain high levels of radon. A sump is created under the building's foundations, and a pipe leading away from the sump should be installed and capped-off at ground-level outside the property. The pipe should include an inline fan, which can be activated at a later date, if the property develops high radon levels. The location of the capping-off should be noted in documentation and with a visual marker so that it can be easily located after the property has been handed over to the owners.

ProTen Services advise that in any area where the HPA has predicted that more than 3% of homes will contain a high level of radon (thus indicating a more widespread occurrence

of the gas and an increased likelihood of exceptionally high concentrations being found), it would be wise for provisions for future remedial work to be made, in addition to the installation of a radon membrane.

Radon protection is a specialist area of work, and should therefore only be carried out by trained specialists. A recent study (Denman *et al*, 2005) found a staggering 60% of radon membranes installed in new properties had failed to prevent the gas from entering the building. Whilst this was a relatively small study, it is nevertheless indicative of serious failure. Likely causes of membrane failures include using a material that is either not gasproof or that is tearable, inadequate jointing, or lack of due care during the installation process. Over the past 10 years it has become accepted that below-ground waterproofing is a specialist area. The history of this area of construction provides a good parallel with radon protection, where effective design, quality of materials and standard of specialist workmanship are paramount.

A crucial aspect of radon protection in new buildings is the need to carry out post-construction testing, to confirm that measures have been effective. This, coupled with a visual inspection of the barrier after it has been laid, will allow the work to be confidently signed off. ProTen Services advise that any contractor who has been employed to provide radon protection should always 'proof it, and then prove it'. If a sump system has been installed, it is impossible to know whether this needs to be commissioned or not, unless a radon test is carried out.

Post-construction remediation

If a building is constructed without any radon protection, it is susceptible to high levels of the

gas being allowed to accumulate inside. The Health and Safety Executive has the power to enforce radon testing in a commercial building, and if the test shows a high concentration of the gas, the employer has a legal duty under the Ionising Radiations Regulations 1999 to reduce the hazard.

Remedial measures can be taken to lower radon concentration, including the use of specialist positive pressure units and the creation of a retrofit sump beneath the property. As with newbuild radon protection, these actions must always be undertaken by a specialist since without the correct understanding of the science of radon passage, it is possible to exacerbate the problem. ProTen Services recently dealt with a property where a general contractor had previously been asked to reduce the radon levels inside a domestic house. The contractor had installed an extract fan, which instead of reducing the radon concentration was in fact increasing the rate at which the gas was drawn into the building, and had ultimately doubled its concentration.

Whilst remedial measures are fairly inexpensive, they will not have been forecast and will therefore present an unbudgeted cost. Additionally, such systems require an annual maintenance and service contract to ensure that they remain effective. When compared with the cost of installing a radon membrane at the time of construction, which would also serve as a damp proof membrane and vapour barrier, it becomes clear that the best course of action for any risk-averse developer or contractor is to install effective radon protection at the time of construction. se

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Fig 2. Laying the radon membrane / Fig 3. 'Top hat' around service pipe