RADON MONITORING AND MITIGATION : EXPERIENCE IN THE UK

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ABSTRACT

Radon has been a public issue in the UK for nearly 20 years. A major National radon measurement programme for existing dwellings was carried out in the mid-1980s, which continues to be followed up with targeted local measurement campaigns. Legislation dealing with radon in the workplace was introduced at the same time followed by requirements for protective measures for new homes in 1988. A large number of measurements have been carried out (more than 500,000 homes measured), but it is only in the last few years that significant public awareness and mitigation has started to happen. This has been achieved via a programme of local authority led campaigns to develop the local infrastructures necessary to raise awareness of, and deal with, radon.

There are essentially three approaches to carrying out radon measurement in buildings. Measurement techniques can be described as instantaneous over a few minutes, short term over five to eight days or long term over several months. Each has advantages and disadvantages but generally the longer the duration the more reliable the result. Government funded measurement programmes across the UK have all used long term measurement with measurement devices placed in homes for a three month period. Shorter term measurements are sometimes used for screening purposes when undertaking mitigation work or at the time of house purchase.

A range of practical low cost mitigation solutions have been developed for use in existing UK buildings. These range from passive solutions such as simple sealing and improved natural ventilation, through to providing mechanical ventilation and dedicated radon extract systems. This paper discusses the approaches being undertaken in the UK to raise awareness and increase the uptake of measurement and subsequent mitigation where necessary.

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INTRODUCTION

Radon has been a health issue in the UK since the National Radiological Protection Board (NRPB) undertook research in the early 1980s and identified areas of the country affected by radon.

Radon is a naturally occurring, colourless, odourless radioactive gas that is found in all soils and rocks. Unfortunately in many parts of the World there are areas in which the natural levels of emission are relatively high, to the extent that, if allowed to build up inside a building, the resulting concentration of radon could increase the occupiers' lifetime risk of developing lung cancer. Whilst elevated radon levels can be found in many areas of the UK, the areas affected are fairly localised. It is estimated that 2000 - 2500 premature deaths due to lung cancer can be attributed to radon in the UK.

For the purposes of this paper we are concentrating on radon in air, although it should be acknowledged that radon can also be found in water and building materials. Fortunately from a UK point of view the problem of radon in water is limited to water drawn from a small number of boreholes in radon affected areas and, whilst radon from building materials can be a significant problem in some countries such as Sweden, the building materials used in the UK do not pose a significant risk.

TESTING FOR RADON IN AIR

Radon measurements are generally described as being passive or active. Passive measurements use radon detectors, which require no electric power or air pumps. They can be classified as either short-term measurements, ranging in duration from 4 to 8 days, or long-term measurements, ranging in duration from several months up to 1 year. Active measurements, on the other hand, use radon detectors which require electric power and/or the use of air pumps to sample the air. These detectors or instruments can be set to sample the air continuously or to take a single grab sample in as little as 5 minutes.

There are four principal types of indoor-radon measuring device:

Etched-track detectors - these consist of a piece of plastic held inside a small container about the size of an air freshener. Radon gas diffuses into the container and decays radioactively, emitting alpha particles which leave invisible damage tracks in the plastic. When the device is returned to the laboratory, the plastic is etched in a caustic solution, producing pits where it has been damaged. The pits are then counted automatically under a microscope. Etched-track detectors are relatively cheap, and suitable for long-term measurements, usually being deployed for three months. These are probably the most widely used method for carrying out large numbers of radon measurements as they are relatively cheap and easy to dispatch by post. The UK national measurement campaigns have used etched-track detectors.

Charcoal detectors - these consist of a small container of activated charcoal, which absorbs radon out of the air. After exposure the detector is sealed and returned to the laboratory, which can measure how much radon is still present. Radon has a 3.8 day half-life, and the radon that is absorbed at the beginning of the exposure decays away after a few days, so the measurement duration is limited and the device does not measure the true average exposure. Charcoal detectors are not suitable for long-term measurements, but may be used when a result is urgently required and a less accurate estimate of annual average concentration is acceptable. These detectors are probably the second most commonly used type of detector, again being of low cost and easy to dispatch by post. They are widely used for screening measurements in house transactions in the USA.

Electret Detectors - an electret is a device which holds an electrostatic charge which is gradually neutralised by the ionisation of the air caused by the alpha particles emitted by radon and its decay products. Measuring the charge on the electret at the beginning and end of an exposure allows the radon concentration to be calculated. In making this calculation, an allowance must be made for ionisation caused by natural background radiation. Different types of electret are available, suitable for measurements over periods of a few days to a few months. Care must be taken with electrets as dropping them can cause a partial discharge and a consequent over estimation of the radon concentration. This and the fact that they are larger in size than etched-track or charcoal detectors means that they are less suitable for postal surveys.

Active measuring devices - various types of electronic monitor are available. Active measurements of radon gas are generally carried out in situations where diagnostic radon testing is being undertaken as part of remedial work in a building. They are also carried out in research work in buildings where information on the temporal and spatial variations in indoor radon levels is required. In theory active measurements carried out over several days in a building could be used in the same way as a short-term passive measurement. However, the cost of such a measurement is prohibitive. All active measurements of radon gas involve either continuous sampling or grab sampling of the ambient air in the building. Most methods use either scintillation detectors or electronic (solid state) detectors. All such detectors or instruments are equipped with inbuilt electronics and readout facilities, and are expensive to purchase. Prices for active radon detectors are of the order of £4000 -£8000.

RADON REDUCTION TECHNIQUES

A range of practical cost effective radon reduction measures have been developed and used in the UK.

There are essentially five ways in which the amount of radon entering a building can be reduced, but they are not all suitable for all types of building and in some cases more than one method may need to be applied. In all cases the aim should be to make a substantial reduction in radon levels, not to reduce it to just below the Action Level.

- *Sealing* - major gaps in or around the ground floor can be sealed to prevent the radon getting through. (although you should not lay a totally impervious sheet over a suspended timber floor as this could result in rotting of the floor.) This is only effective at low radon levels (200 Bq/m^3 - 400 Bq/m^3) and generally it is difficult to reduce the radon level to much less than half of the initial level by this means.

- *Improved ventilation* - you can in some cases change the way in which a building is ventilated, to avoid, as far as possible, drawing air and radon through the floor; but as this generally depends on the occupants' behaviour it is not a particularly reliable remedy.

- *Improved underfloor ventilation* - the flow of air under a suspended floor can be increased. This is generally fairly effective, particularly when fan assisted, and will also reduce the risk of rot in timber floors. (200 Bq/m^3 - 600 Bq/m^3)

- *Whole house pressurisation* - you can pressurise the building with a fan drawing air from the loft space. This method is again generally only effective at moderate radon levels and it is difficult to reduce radon levels to much less than one third of the initial level by this means. (up to 700 Bq/m^3)

- *Sub-slab depressurisation or sump system* – it is possible to reverse the natural stack or chimney effect of a house by depressurising the soil beneath a building. This is achieved by installing a fan and pipework to draw air from a sump created beneath the floor. This is generally the most effective method and in many cases will reduce the radon level to less than one tenth of the original level. It is generally only practical for buildings with solid concrete floors or suspended floors where there is a layer of concrete capping the soil below. Where there is no capping to the soil one has to be provided, which can prove relatively disruptive and expensive to install.

THE UK RADON PROGRAMME

The UK Government's radon programme for England began in 1987. Following advice from the NRPB the government set a recommended action for indoor radon levels in the home of 200 Bq/m^3. Householders with levels exceeding the action level being advised to take action to reduce the level to well below 200 bq/m3. The UK radon programme focussed on four issues :

- *Measurement programme* - this was largely undertaken by the National Radiological Protection Board (NRPB) and was aimed at identifying homes with elevated radon levels throughout the country. Earlier studies had identified the areas most likely to be affected so measurement was generally directed towards these areas. However measurement was also carried out in the lower risk areas so that in 1996 NRPB were able to publish a detailed map of affected areas throughout England. Throughout the period 1987 to 1995 free measurements were available to householders on demand, as well as those provided as part of targeted campaigns. Since 1996 free measurements have only been available in targeted campaigns in areas most likely to be affected by radon - essentially areas with a greater than 1% probability of being above the Action Level. These campaigns achieved greater than 30% response rates. Since 1998 free measurement has been further refined with invitations sent to every home in England with a greater than 5% probability of being above the Action Level. More than 400 000 measurements have been carried out since 1987. All measurements are carried out using etched track detectors

- *Research* - funding research looking at health risks and measurement largely undertaken by NRPB, and research into the development of practical cost effective remedial measures for existing buildings and protective measures for new buildings largely undertaken by BRE.

- *Regulations* - requirements were introduced to reduce the risk from radon in the workplace. The Building Regulations were amended and supporting guidance introduced to provide adequate protective measures in new buildings in radon affected areas.

- *Grants* - means tested grants for the most needy were made available for the installation of radon remedial measures

A CHANGE IN APPROACH

Whilst the work carried out between 1987 and 1997 had been reasonably successful in measuring homes and developing techniques for combating radon the levels of remediation remained low - probably no more than 10%-20% of houses identified as having a problem being remediated. Research had shown that there were many reasons for this, including a lack of understanding of the health implications, lack of knowledge of what to do, the cost of remediation, lack of confidence in local builders, and the possible effect on property prices. A significant factor however, had been the remoteness of the campaign. The radon issue was seen as being yet another government initiative being forced upon people in the regions. Unfortunately the approach taken to running the various radon measurement campaigns had not helped in this. Whilst the offer of free testing had been successful in encouraging some 30-40% of householders in affected areas to have their homes tested, it had not helped to encourage remediation. This is largely because invitations, and the despatch of detectors and results, were all undertaken by post – there was no human interface. The result was that householders receiving elevated radon readings for their homes felt that they were left on their own to resolve the problem and that there was no local help.

RADON PILOT STUDY

Recognising there was a need to make radon more of a local issue and to help create a local radon infrastructure, the UK government funded a pilot study between 1998-2000, to see if local authorities could be used as a focus for raising public awareness and encouraging remediation. The aim was for the local authorities to provide the public face of the initiative and government to provide background support. The pilot studies were organised with 3 local authorities. Two of these, Derbyshire Dales and Mendip, were long established radon affected areas whilst the third, Cherwell, was relatively new. The studies did not target all homes within each local authority district, only those areas with homes with a greater than 5% probability of being above the Action Level. Government support included providing :

- "Free" radon measurements to identify homes above the Action Level, and to confirm whether remedial action had worked
- Expert advice from NRPB to local authorities, local medical community and householders about the health effects of radon
- Expert advice from BRE to local authorities, local builders and housing professionals and householders about remediation methods
- Locally branded publicity materials to meet local councils' needs
- Consultants to help local authorities develop local strategies (Action Plans)

The general approach taken by the three local authorities was essentially the same although each tailored its campaign to reflect past activities and resources available locally. In each area two categories of householder were targeted :

- *High testers* - all householders known to have elevated radon levels and thought not to have remediated.
- *First time testers* - all householders who had not previously had a radon test but who were in >5% probability risk areas.

Invitation letters were sent out by NRPB with a letter from the local authority encouraging testing and offering local points of contact for people seeking further information or guidance.

Various approaches were tried to raise public awareness generally in each area to increase the uptake of testing and remediation. This included targeted local press, radio and TV coverage and in one area organising a "Radon Month" with concentrated public awareness activities over a one month period. This was all supplemented by locally branded publicity material, including posters, bookmarks and leaflets.

General awareness activities were supplemented by a series of seminar and training events to improve understanding and provide technical support within in local authorities and for construction professionals. The intention being to build a local infrastructure of radon knowledge in each area. These included seminars for :

- *Local authority staff,* whether directly or indirectly involved in the local campaign. This included technical training for environmental health, building control, and housing professionals who were directly involved in advising householders of remediation options. Support staff such as receptionists were also provided with radon awareness training so that they could respond positively as the first point of contact for householders seeking technical advice.
- *Local builders* were given short training courses outlining the principle radon remediation techniques.
- *Health professionals*, including local doctors, who can advise householders with health concerns.
- *Housing professionals,* including surveyors, estate agents and solicitors in order to allay fears about blight and to ensure that radon is seen to be just another building problem that is dealt with at the time of house purchase.

It was clear that if uptake of remedial measures was to be increased it was essential for the local authorities to provide some hand holding to make it easier for the householder to carry out works. Depending upon staff availability various different approaches to making direct contact with householders were used :

- *Home visits* - officers visiting householders with elevated levels to advise on possible remedial techniques and how to carry out the work.
- *Radon surgeries* - householders invited to attend a local venue to obtain advice on possible remediation techniques, and how to carry out the work, from technical experts from BRE and local authority staff.
- *Roadshow events* - householders invited to attend a local venue to obtain advice and guidance on radon risks and possible remedial techniques from technical experts from NRPB, BRE and local authority staff.
- *Telephone* - householders invited to phone dedicated radon advice lines for advice

CONCLUSIONS FROM THE PILOT STUDY

The pilot study proved to be very effective. There was a significant increase in the number of houses measured but probably more importantly there had been a doubling of the number of houses remediated. It was felt that a number of factors had influenced this success :

- Local delivery of advice and support
- Effective targeting of key groups
- Optimum use of technical expertise from NRPB and BRE
- Deployment of simple consistent messages on health risks and remediation methods
- Minimising effort demanded of householders
- Sustained support and follow-up contact by the local authority

THE 'ROLL-OUT' PROGRAMME

With the pilot programme proving so successful the approach has since been rolled out to more local authorities across England. The 'Roll-Out' programme, which commenced in 2000 and is currently intended to run until 2005, aims to improve the amount of remediation amongst radon-affected households, to continue to raise awareness about radon, and to deliver this initiative at a local level. 78 Local Authorities with >5% probability areas in their districts were invited to participate in the programme. Of these about 30 Local Authorities have taken up the offer and are participating, working in 12 local groupings.

Whilst the programme is still ongoing early indications look positive with a further increase of around 30% uptake of free measurement (range 20% - 55%). There also appears to be strong interest in carrying out remediation by householders. Interestingly the best response from the public appears to be in areas where senior local authority staff are getting involved in the programme. The programme is about to be reviewed with a view to seeing how successful it has been and to help shape any extension of the programme to include additional local authorities.

The Welsh Assembly Government are planning to run a similar programme for homes in Wales.

CONCLUSION

Since the mid-1980's the UK government has funded a series of radon programmes aimed at identifying radon affected areas and affected buildings, raising public awareness of the problem, developing appropriate reduction measures for existing buildings and developing protective measures for new buildings. Experience gained through these programmes has resulted in the creation of a highly successful government supported, local authority led, approach to raising awareness of radon risk, measurement and remediation. This 'Roll-Out' programme is helping to build a local infrastructure of radon knowledge which is raising local interest in radon and its remediation. The approach brings together everybody associated with buildings from the householder, local authority, builders, surveyors, solicitors, estate agents and health professionals. Initial results show that the programme is resulting in a significant increase in the uptake of radon remedial measures and reduction in indoor radon levels in the 'Roll-Out' areas.