THE UK MINISTRY OF DEFENCE RADON SAFETY PROGRAMME

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Abstract

The Radon Safety Programme (RSP) for the UK Ministry of Defence (MoD) estate has been in place since 2005 and as of July 2012 has installed 14,000 radon detectors. The UK has statutory legislation in place to protect employees from radon exposure and the MoD has established a robust policy to ensure the health and safety of its personnel.

The RSP covers thousands of workplace areas including caves, underground bunkers, armouries and office buildings, with the aim of protecting the health of military and non-military personnel now and in the future.

MoD also implements a duty of care policy that extends beyond the workplace to include barrack accommodation and military family accommodation. Communication of the radon risk in an appropriate way is essential to those tenants.

Introduction

The UK has statutory legislation (Health & Safety at Work 1974 Act and the Management of Health & Safety at Work Act (MHSWR99)) that ensures the protection of employees in their work environments. Whilst this legislation is robust, it is not comprehensive enough to protect employees from radiation exposure and The Ionising Radiations Regulations 1999 (IRR99) were constituted to ensure that employers protect their employees from ionising radiation and that any exposure is kept as low as is reasonably practicable (ALARP). Under IRR99, the workplace radon gas concentration Action Level is 400Bq m^{-3} (becquerels per cubic metre), which equates to a dose of approximately 2mSv per year based on an average occupancy of 1600 hours. There is no statutory legislation in place in respect to domestic properties but the UK's Health Protection Agency (HPA) provides guidelines recommending an Action Level of 200 Bq m^{-3}.

The MoD adheres to both the IRR99 and the HPA guidelines when protecting its employees from radon exposure (as well as extending a duty of care to service personnel families). It has instigated mandatory requirements that are often more robust than that required by the legislation. Under its' Joint Service Publication No. 392: Radiation Safety Handbook, arrangements for protecting against radon are clearly defined.

The Defence Science and Technology Laboratory (Dstl) is an agency of the MoD and has been appointed as the Radiation Protection Adviser to provide advice on a wide variety of radiation protection issues, including radon. Dstl implemented a comprehensive radon monitoring programme across the MoD estate in 2005. The MoD estate is extensive and covers workplace and domestic properties across the British Isles, as well as at overseas locations within Canada, Gibraltar, Cyprus, Germany, Nepal, Brunei, Falkland Islands, and

Diego Garcia. Whilst its' domestic properties (houses or apartments albeit of various ages and styles of architecture) are fairly standard, the workplace accommodation is extremely diverse. MoD employees can work in office blocks, underground storage areas, caves, aircraft hangars, museums , or remote radar cabins. The vast majority of these employees are in roles which do not require any knowledge of the hazards and risks from ionising radiation. It is generally these personnel, as well as the families of military personnel, to whom communication of the risk from radon has to be carefully managed.

Monitoring programme

Monitoring Programme Strategy

A combination of previous radon monitoring and geological mapping, carried out by the HPA and the British geological Survey (BGS), have identified Radon Affected Areas (RAAs) within the UK and presented these as maps and as a large dataset. RAAs are defined as those areas with 1% or more of homes at or above the recommended Action Level of 200Bq m^{-3}. Although the statutory Action Level for workplace areas is 400Bq m^{-3}, the RAA dataset was used as a starting point for the MoD Radon Safety Programme (RSP).

Initially, all MoD establishments located in or adjacent to a RAA or those with underground facilities were monitored. This was then extended to barrack accommodation (Single Living Accommodation (SLA)).

Where MoD employees are working as instructors on vocational training courses in caves (or in underground areas) both environmental and personnel monitoring is undertaken.

Additionally, where finances have allowed, a significant number of sites that do not fall into a RAA have been monitored for reassurance purposes. This has meant that the majority of Royal Air Force (RAF) and Royal Naval shore based sites, as well as a high percentage of British Army sites, have now been monitored.

Despite the knowledge that levels can vary drastically within buildings and even between adjacent rooms, financial constraints and the large size of the MoD Estate have prohibited the monitoring of every room and every building. Therefore a risk based approach has been implemented, with the location and numbers of detectors used being based on the building size, construction, occupancy and ventilation rates, whilst ensuring a representative geographical coverage of the whole site. The RSP also includes the requirement to re-monitor MoD establishments in RAAs on a five yearly basis which should over time ensure all buildings are monitored.

Dstl review the locations of all units on an annual basis to ensure no new sites have been established within RAAs and undertake further reassurance monitoring at all sites where remediation measures are installed.

In conjunction with the Dstl monitoring programme, the Estates division of MoD monitors the Service Family Accommodation (SFA).

Description of Radon Detectors

Monitoring is carried out using passive radon detectors. The detector consists of a TASTRAK^{TM} etched-track detection element housed inside a NRPB/SSI holder (*Langridge et al 2010*). The radon-daughter decay alpha particles leave tracks of damage on the surface of the TASTRACK^{TM} element that are enlarged by a chemical etch process and then counted using a TASL reader within the Dstl radiation detection laboratories.

Figure 1: Dstl radon detector

Standard Advice Procedures

A formal procedure is employed for establishments where monitoring results indicate elevated levels of radon that includes both verbal and written communications, risk assessments, short term remediation recommendations and the appointment of a Workplace Supervisor. Table 1 shows a summary of the actions required.

The advice provided is dependent on the building(s) usage and occupancy figures and is designed to ensure that exposure is kept ALARP.

The appointment of a Workplace Supervisor (WPS) is made to manage the radon risk and to ensure that the advice provided by the RPA is actioned. A further vital role for the WPS is to communicate the risk from radon to the affected personnel.

As indicated in Table 1, under IRR99, all areas with elevated radon results are required to produce a risk assessment. Dstl often produces this in conjunction with the WPS. The risk assessment will include an assessment of the potential radiation doses and, where required, a recommendation for remediation to be instigated. Where engineered remediation measures are recommended, Dstl advise the appointment of a specialist radon remediation contractor. This contractor would then be tasked by the site management to undertake more extensive monitoring throughout the building and assess which type of system is best suited to reduce radon levels. Following installation of a remedial system, further monitoring is required to ensure that the remediation measures installed are effective. There are two types of engineered remediation generally used on MoD estates: positive ventilation and active sumps.

Although there is no statutory requirement for risk assessments to be completed for dwellings with high radon results, Dstl provides a risk summary that mirrors the workplace risk assessment.

In respect to SLA with high radon levels, in most circumstances, the particular room(s) can be vacated and remain so until such time as the building has undergone remediation. In most areas, this is not a problem as MoD is currently in the process of refurbishing a significant proportion of its living accommodation and radon mitigation/remediation is now included in this refurbishment programme.

Table 1 Actions required depending on radon monitoring result (based on 3-month environmental monitoring)

Concentration level (Bq m-3)	Action required
> 400	Ionising Radiations Regulations 1999 apply. HSE Notification required. Consult RPA. Appoint WPS (Radon) or possibly RPS. Restrict exposure. Re-monitor annually in winter months. Monitor radon levels until remediation measures are installed. Keep MHSWR99 radon risk assessment under review.
Between 300 and 400	Consult RPA. Appoint WPS (Radon). Re-monitor annually in winter months (keep situation under review to ensure that if working use or conditions alter the radon concentrations are re-monitored). Consider, in consultation with RPA immediate action to reduce exposure, e.g. increase ventilation. Keep MHSWR99 radon risk assessment under review.
≥ 200, but <300	Consult RPA. Re-monitor within five years (keep situation under review to ensure that if working use or conditions alter the radon concentrations are re-monitored). Appoint WPS (Radon). Keep MHSWR99 radon risk assessment under review.
< 200	Keep MHSWR99 radon risk assessment under review.

Results

The majority of monitoring results were in accordance with the HPA data in that MoD sites in RRAs (such as Yorkshire, Wales, Devon and Cornwall), tended to have higher radon gas concentrations. Table 2 shows a sample range of results above the Action Levels, all of which fall in an RAA. In addition, a small number of sites that had been monitored for reassurance purposes (which were not in an RAA) returned results above the respective action levels.

Table 2 Sample range of radon gas concentration levels across various MoD sites

Location	Rn Gas Concentration (Bq/m^3)
Workplace:	
Plymouth, Devon	629
Brecon, Wales	1366
Scunthorpe, Yorkshire	1356
Grantham, Lincolnshire	619
Catterick, Yorkshire	1507
Newquay, Devon	521
Barry, Wales	485
Single Living Accommodation:	
Hook, Hampshire	813
Catterick, Yorkshire	867
Rutland, Yorkshire	696

Key Issues of Concern

Underground Facilities

Whilst the advice and the subsequent remediation actions in respect to the general workplace and SLA areas can be straight-forward, as previously mentioned, the MoD estate consists of varied types of premises such as underground facilities and caves where the standard advice and subsequent actions would not be feasible.

A number of these workplace sites with underground facilities (armouries, bunkers etc) have recorded results well above the Action Levels (>1000Bq m^{-3}). The use of engineering controls in these locations can be prohibitively expensive or impractical. Thus limiting the amount of time employee's work in those areas is sometimes the only option to ensure radiation doses are kept ALARP.

One particular group of concern are the military personnel who run caving expeditions. Remediation of these caves is not feasible and, as there are often high levels of radon in caves, the instructors are at risk of receiving high radiation doses. These instructors adhere to systems of work (e.g. only operating in caves where radon levels have previously been assessed, limiting their time in certain areas etc.) to ensure their exposure is kept ALARP. Personal radon dosimeters are issued on a quarterly basis to assess their exposures to determine whether the safe systems of work remain effective.

Another issue with these MoD employees is that, as they are often serving military personnel, they can be posted off-site at short notice and communication of the systems of work and the

radon risk can sometimes be insufficient or neglected. This has resulted in individual dosemeters not being worn or being stored incorrectly. This is currently being reviewed and more frequent training and regular reviews of their written operating procedures are being proposed as ways of highlighting the risks from radon and the importance of measuring their radiation exposure correctly.

Private Contractors Responsible for On-Site Facilities

Despite the RPA advising establishments to ensure a specialist radon contractor was appointed and that the RPA should be consulted prior to remediation being installed, this did not always happen. One of the main reasons is that the infrastructure is always managed by a facilities contractor on behalf of the MoD estate organisation who, until recently, had not appointed their own RPA. The facilities contractor would instruct their building contractor who in turn should have appointed a radon specialist contractor. The result of this was a mixture of inappropriate and ineffective remediation measures being installed which then delayed the correct measures being installed, or (in some locations) over-engineered solutions being installed which were effective but at an exorbitant cost. The MoD estate organisation has recently appointed Dstl as their RPA and it is now hoped that this will result in better communication throughout the remediation process.

Communication of the Radon Risk: Case Studies

When communicating the radon risk, the RPA first needs to assess who is requesting the information and advice needs to be adapted to suit. The two case studies below highlight that whilst information on the radon risk and the potential doses can be similar, the method and content of the information provided may need to be different dependent on who is being addressed – one was to an emotional individual and the other to personnel with a good technical understanding.

Case Study 1 – *Hampshire*

Workplace monitoring was first undertaken over the winter months of 2008/2009. Radon measurements in a number of rooms in one building were between 400 and 691 Bq m^{-3} and engineered remediation was recommended. Subsequently two sumps were installed at the front wings of this H-shaped building by a specialist radon contractor and monitoring continued for reassurance purposes. Following installation of the engineered solution, most of the rooms in the building contained radon concentrations well below the Action Level. However, one room at the other end of one of the wings (Room A) had a significantly increased radon concentration from 395 Bq m^{-3} to 1473 Bq m^{-3} . The radon specialist was consulted and could not offer any explanation for this rapid increase.

The occupier of Room A was informed of the situation and instructed to increase the ventilation within the room. Although they were aware of the previous radon work that was undertaken in the building, (as they were now being directly affected), they undertook their own research via the Internet, discovering that radon is a radioactive gas. As they felt the risk of radiation exposure had not been communicated appropriately, they consulted their trade union representative, who raised the issue through the chain of command. Dstl personnel were asked to meet with the individual.

During the meeting, it was discovered that the employee had worked in the same room for nearly thirty years, and had been prone to working 50-hour weeks on a regular basis in the past. The individual was also a smoker (increasing the risk of lung cancer) and felt the cold so tended not to ventilate the room. It was also clear that when the high results were recorded in 2009 and manual ventilation measures were instigated, the radon risk had not been communicated effectively to those people who were potentially affected. Dstl discussed the radon risk in an informal way and subsequent feedback indicated that the individual had been reassured. The hand out that Dstl prepared for the meeting which explained radon in a simple and less scientific format, is now made available to all WPS appointees. This is proving an effective tool for communicating the risk from radon.

Case Study 2 – Lincolnshire

Monitoring first started on this site in 2007. Radon concentrations measured in two buildings showed results of between 400 – 975 Bq m^{-3}. Both buildings were fully occupied. Manual ventilation was instigated and a request for remediation was sent to the MoD department that fund building works. Initially funding was agreed and the remediation works scheduled, but then the remediation work was postponed. The Commanding Officer decided to take this up the chain of command and Dstl were asked by the Army Medical Directorate and the Army Scientific Advisor to provide a report on the potential radiation doses to the personnel from the radon exposure and to justify our recommendations that the affected rooms in each building should be vacated. Whilst the radon risk was similar to Case Study 1, the information that was provided to justify the case for expenditure needed to be presented in technical detail and to be very robust.

Lessons Learnt

It has become clear over the period of the RSP that RPA advice and recommendations needs to be tailored for the site and people in question (whilst still adhering to MoD policy).

During the early stages of the RSP, when elevated radon levels were discovered in one or two rooms, the policy was to re-monitor all the rooms in the buildings to ensure the radon profile of the whole building was understood. It was at this point that the RPA advised the employer to consult a suitable contractor. The current policy is to now advise the employer immediately when results are above the Action Levels in order for them to instigate remediation measures and monitoring continues until such time as the remediation measures are in position (as well as afterwards for a period of time for reassurance purposes).

This change in approach means that remediation measures are in place more rapidly and this has decreased delays and reduced ionising radiation doses to personal.

The monitoring programme was originally conducted on a risk-based approach and only establishments within a RAA were monitored. It was only due to funding becoming available that selected sites in non-RAAs were monitored and some were discovered to have elevated radon levels. This has resulted in a change in the monitoring programme policy with the intention that all establishments will eventually be monitored.

As many people who work in an RAA will live close to where they work and thus are likely to live in the RAA, the current policy is to now request the establishments in RAAs to raise

the profile of the risks from radon and to highlight the importance of radon monitoring at home. The establishment's health and safety team are often used to facilitate this.

Conclusion

The MoD estate covers a wide range of property that has radon issues. It takes its' duty of care seriously, whether statutory or not, to all individuals potentially affected. The MoD Radon Safety Programme is well established and has robust requirements for sites with elevated radon levels.

It is clear from Dstl's experience that as the MoD estate is so varied, and that the individuals using that estate have very different levels of understanding of radon and radioactivity, communication of the radon risk cannot be delivered in a uniform style. It must be tailored towards site and personnel specific requirements. It is essential that an individual's fears or concerns are not forgotten. This communication should also be extended to include all the stakeholders on a site such as the facility contractor.

In the near future, the monitoring programme will be extended to all sites not in an RAA and also to MoD's overseas locations, to ensure that all the estate has been reviewed and remediated where necessary.

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