

# 32 Radiation Safety Arrangements for Protection Against Radon

## Scope

1. Radon is a naturally occurring odourless, colourless radioactive gas. It is generated by the radioactive decay of uranium in minerals and rocks such as granite, or from radium-luminised articles. Radon can build up in indoor areas, particularly underground, such as mines or basements, or in poorly ventilated areas. Radon enters indoor areas from the ground through any gaps or cracks in the fabric of the building.
2. Radon exposure contributes around half the annual average radiation dose to people in the UK and according to the World Health Organisation is the second leading cause of lung cancer worldwide.
3. This Chapter describes the radiological requirements for control of exposure to radon. The information provided in the main body of this Chapter is primarily directed to workplaces, for which the Ionising Radiation Regulations 2017 applies. Radiation safety arrangements for protection against radon exposure in residential accommodation is provided at Annex A. General information and instruction on the hazards associated with radon, personnel duties and responsibilities and statutory and MOD mandatory requirements is provided in the body of the Chapter. The RPA is to be consulted for detailed advice on specific areas affected by radon and for locations overseas.

## Statutory Requirements and Parallel Arrangements

4. In addition to the general requirements of the Health and Safety at Work etc., Act 1974 and the Management of Health and Safety at Work Regulations 1999 (MHSWR99), the following specific legislation applies directly or is applied indirectly through parallel arrangements designed to achieve equivalent standards in respect to workplace areas:
  - a. Ionising Radiations Regulations 2017 (IRR17) (apply directly)

## Duties – workplace only

5. Duties as detailed in Chapter 39 apply. In addition, the following duties also apply.

### Workplace Supervisor (WPS) (Radon)

6. In units or establishments where radon activity concentrations are equal to or exceed  $300 \text{ Bq m}^{-3}$  (averaged annually) but where it is not necessary to appoint an RPS, a WPS (Radon) is to be appropriately trained and appointed. Duties will be to ensure that work is carried out in accordance with the local orders for radiation safety and include the requirements detailed in this Chapter.

7. These duties should include the following:
  - a. determine any changes in ventilation and / or occupation rates in a particular area which may affect radon activity concentrations and potential radiation doses;

- b. ensure, where remediation measures are installed, they are functioning efficiently and correctly, and that maintenance is undertaken as directed;
- c. act as, or oversee, the coordinator for the issuing of any personal radon dosimetry; and
- d. act as, or oversee, the coordinator for active or passive radon monitoring, including (where relevant) the placement and collection of environmental radon detectors.

### **Radiation Protection Adviser (RPA)**

8. Every employer engaged in work with, or at risk of being exposed to, ionising radiation, which includes workplaces where the concentration of radon in the air exceeds  $300 \text{ Bqm}^{-3}$ , must consult and appoint a Radiation Protection Adviser (RPA). The RPA can provide advice on, but not limited to, monitoring programmes, local orders, training, dose constraints, plans for new installations in respect to engineered remediation, and risk assessments.

### **Defence Infrastructure Organisation**

9. The Defence Infrastructure Organisation (DIO) is responsible for ensuring that the estate as whole remains safe from radon exposure for all those who live, work and train at the MOD.

### **Maintenance Management Organisation and their Sub Contractors**

10. The Maintenance Management Organisation (MMO) will manage the radon programme on behalf of DIO for Service Family Accommodation (SFA) on the MOD estate. They will appoint radon specialist subcontractors to provide dosimetry services and remediation installation. Further details on the management of the SFA radon programme can be found at Annex A.

### **Responsibilities**

11. The responsibility for implementing radon management in workplace areas falls to the individual employer e.g. Army, RAF etc., and also includes Single Living Accommodation (SLA). The HoE / CO delegates the duties to the site / station / unit's Radiation Safety Officer and that individual is the point of contact for the RPA and Approved Dosimetry Service.

12. All other accommodation is managed by the Maintenance Management Organisation (MMO) on behalf of DIO. The MMO is required to appoint an RPA.

### **Nature of radon**

13. Radon gas is primarily radon-222 ( $\text{Rn-222}$ ), which has a short half-life (approximately 4 days) and once mobilised into the air, decays through a number of radioactive short-lived radon progeny (also called 'daughter products' or 'decay products'). When radon gas is allowed to build up in an enclosed space, such as a mine or basement, the radioactive hazard increases because of the build-up of radon progeny. The relative amounts of radon progeny to radon gas depends upon ventilation, and radon ingress rates, with well-ventilated areas usually containing lower concentrations of radon progeny.

14. The majority of radon gas that is inhaled is immediately exhaled and presents little radiological hazard. However, the hazard connected to radon, i.e. the increased risk of lung cancers, is associated with inhalation and deposition of short-lived radon progeny in the lung. Subsequent to deposition within parts of the lung, tissue is irradiated causing the increased risk of cancer.

15. Though it is not the radon gas itself which causes the hazard, in most scenarios the concentration of radon is directly proportional to the hazard. As radon is more easily measured than its short-lived progeny, it is the radon levels that are currently used to estimate the potential risk.

16. As radon is a gas, the air activity concentration is measured. The units used are Becquerels per cubic meter ( $\text{Bq m}^{-3}$ ).

17. Work environments vary greatly in size and nature, but significant levels of radon gas can occur in almost any type of workplace. The amount of radon that collects in a building depends on its location, structure, construction materials and how it is used. In workplaces such as offices, where hazards are normally low, radon can be the largest occupational health risk.

### **Radon affected areas and UK action levels**

18. Radon affected areas (RAA) in the UK have been identified by Public Health England (PHE) in conjunction with the British Geological Survey (BGS) using measurements made in homes over a number of years together with geological data. Figure 1 represents the estimated percentage of houses above the Action Level  $200 \text{ Bq m}^{-3}$  (averaged annually) per 1 km grid square for dwellings in England and Wales<sup>1</sup>. RAAs are defined as those with at least 1 % probability of having radon concentrations at or above the UK Action Level in homes. PHE operate an interactive radon map which can be used to find out if a site in the UK is in a RAA, which can be accessed at: <https://www.ukradon.org/information/ukmaps>. Alternatively, the Dstl RPA can be contacted for support.

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<sup>1</sup> Maps for Scotland, and Northern Ireland, as well as the interactive map can be found at the link below <https://www.ukradon.org/information/ukmaps>

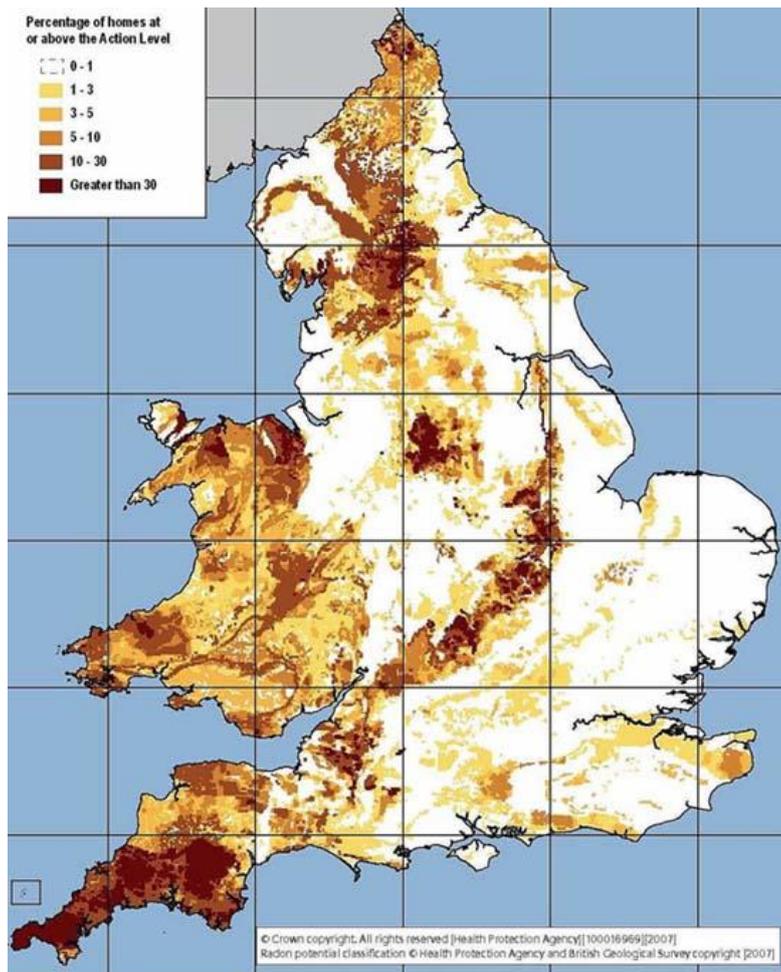


Figure 1 Estimated percentage of houses at or above the radon Action Level for homes ( $200 \text{ Bq m}^{-3}$ ) in England and Wales\* (PHE)

19. The Action Level for workplaces is  $300 \text{ Bq m}^{-3}$  (averaged annually). This is higher than the Action Level for homes because people generally spend more time at home in comparison to work. A radon gas concentration of  $300 \text{ Bq m}^{-3}$  (averaged annually) equates to a radiation dose of approximately  $2\text{mSv}$  per year based on occupancy of 2000 hours (using ICRP65 dose coefficients).

### Measurement of Radon

20. The CO / HoE has the responsibility to adhere to MHSWR99 which requires that the site / unit undertake a risk assessment, this should include an assessment of whether radon monitoring is required. Radon monitoring should be undertaken in workplaces located within a RAA or any underground area occupied for more than 50 hours per year or an average of one hour per week (owing to the expected elevated radon in all underground areas irrespective of location).

21. In addition, where TLBs make use of non-MOD property to conduct some areas of their business in known RAAs (e.g. cadet units operating from the volunteer estate) the CO / HoE has a responsibility to seek assurance from the operator / landlord of those premises (or the appropriate regional RFCA council) to ensure that the risks from radon exposure have been adequately addressed.

22. The RPA should be consulted on the arrangements that should be in place for the monitoring of radon in wholly underground workplaces such as mines, tunnels and caves and in workplaces where other sources of radon such as radium-luminised dials are kept, for example museums and heritage centres.



Figure 2 A Dstl ADS radon detector

23. Passive measurement of radon concentrations in situ is the method currently recommended to assess radiation exposures. Radon environmental detectors, as shown in Figure 2, are used by Dstl Approved Dosimetry Services (ADS) to assess the radon concentration present in an area. Where measurement is required, the CO / HoE has the responsibility to ensure that radon detectors are requested from Dstl Radiation Sciences, this request may be delegated to the RSO, WPS (Radon), or other POC representing the site / unit. Radon detectors can be requested by contacting the RPA or ADS directly using the contact detail provided in paragraph 34.

24. If monitoring has been performed in the past and there has been a change which may affect ventilation (e.g. double glazing has been installed), or no radon monitoring has been conducted within the past ten years, then advice should be sought from the Dstl RPA.

25. Detectors are placed for a 3-month period to take into account average conditions within the building. Radon detectors should be distributed in ground floor rooms that are used routinely. Other rooms, on higher floors or those in which people spend little time do not generally need to be tested. The number of detectors required depends on the use and size of the area and occupancy. A decision on the number required should be made between the RPA and the WPS (Radon) / POC. Table 1 provides guidance to assist decision making on the number of detectors required.

Table 1: Guidance for the number of radon monitors required per area (Adapted from PHE table: <https://www.ukradon.org/information/workplace>)

Workplace type	Number of monitors	Examples
Small or individual office	One per 100 m <sup>2</sup> . This generally corresponds to between a half and third of all ground floor rooms	Offices, dental surgeries, single living accommodation
Open plan office, and retail or workshop up to about 1000 m <sup>2</sup> , also public access areas	One per 250 m <sup>2</sup>	Larger offices, armouries, training classrooms,
As above, up to 5000 m <sup>2</sup>	One per 500 m <sup>2</sup>	Very large open plan office plates, warehouses
Basements	One in each separate room, section or area irrespective of size, if occupied more than 50 hours per year	Offices
Wholly underground	As a guide at least one in each main working area, and other normally occupied areas, but seek specialist advice	Mines, caves, bespoke uses

## Placement of radon detectors

26. Information regarding placement will be sent by Dstl ADS with the radon monitors. The documentation will also include an Issue List which must be completed by the individuals placing the monitors to record the position and issue and collection date. Contact Dstl if further information or assistance is required.

## Results of Radon Monitoring and Subsequent Actions

### Workplace Areas

27. Radon concentrations are determined after the application of a 'seasonal correction factor' which accounts for the seasonal variation in radon concentrations due to temperature and pressure differences throughout the year. Once the results are available, Dstl will send these in writing to the POC and will include advice on any further actions if required. Table 2 details what advice might be provided dependent on the results. Where the results are such that there is concern that the occupants may be at risk of exposure to high radon levels, Dstl will contact the POC by telephone to provide immediate advice on mitigating the risk.

Table 2 Actions required by the IRR17 following radon monitoring results (based on 3-month environmental monitoring)

Type of Monitoring Location	Concentration level (Bq m <sup>-3</sup> , averaged annually)	Action required
Workplace	> 299	<p>Installation of mitigation measures (engineered remediation) by specialist radon mitigation contractors. A list of UK Radon Association approved contractors can be found here: <a href="http://www.radonassociation.co.uk/services/radon-mitigation/">http://www.radonassociation.co.uk/services/radon-mitigation/</a></p> <p>OR</p> <p><b>Ionising Radiations Regulations 2017 apply</b></p> <p>Consult RPA</p> <p>Appointment and training of WPS / RPS (for RPS requirement see below)</p> <p>Restrict exposure to personnel by occupancy limitation (i.e. restricting access to high radon concentration areas)</p> <p>Produce work instruction / local orders to record occupancy limitation</p> <p>Produce Radiation Risk Assessment for radon exposure required including radiation dose assessment to personnel in areas exceeding the Action Level. Review this on an annual basis or when a material change occurs (e.g. change in area use, change in radon concentration)</p> <p>HSE Notification (already done in most instances at TLB level)</p> <p>Possibility of the requirement to designate areas as Controlled or Supervised. This would require additional training and appointment of an RPS and potentially many other administrative and practical measures</p> <p>Possibility of the requirement to designate Classified Persons. This would require many other administrative and practical measures</p> <p>Conduct regular further monitoring</p> <p>Provide personnel coming into the area information regarding the hazard in area</p>

		Keep IRR17 Radiation Risk Assessment
Workplace	≥ 250, but < 299	Consult RPA Re-monitor within the next five years Keep MHSWR99 radon risk assessment under review
Workplace	< 250	Re-monitor within the next 10 years Keep MHSWR99 radon risk assessment under review

### Radon from storage of radium-226

28. Where reasonably practicable, items containing radium-226 are to be stored on open racking within a secure, well-ventilated store with a volume exceeding 25 m<sup>3</sup>. Any additional radiation protection requirements due to radon exposure will be addressed in the Radiation Risk Assessment for storage / use of these items and should be adhered to. Where a significant amount of radium-226 is held and / or the storage volume / ventilation is small, radon monitoring will be required. Advice on radon monitoring should be requested from the RPA where items containing radium-226 are stored.

### New buildings

29. For new buildings, extensions, conversions and refurbishment works, it is a requirement to comply with Building Regulations (BR) 2010. These Regulations refer to using BR 211(updated 2015) (Guidance on Protective Measures for New Buildings) which presents detailed information on where protection from radon is required and also provides construction details on methods of protection. For overseas locations specific advice is to be sought from the RPA.

### Legal and MOD mandatory requirements

30. Table 3 below summarises the legal and MOD mandatory requirements for control of radon exposure in the workplace. In cases of doubt, the RPA is to be consulted for advice.

Table 3 Legal and MOD\* mandatory requirements for control of radon exposures

Requirement	Applicable	Comments
HSE Notification	✓	Where radon concentrations are greater than 300 Bqm <sup>-3</sup> (averaged annually) the HSE is to be notified.
Risk assessment	✓	A risk assessment is required under MHSWR99 to assess the exposure to radon. A Radiation Risk Assessment under the Ionising Radiations Regulations 2017 is required where radon concentrations are greater than 300 Bq m <sup>-3</sup> (averaged annually) and no engineered mitigation measures are planned. The RPA can be contacted for specific advice on this.
Restriction of exposure	✓	Restriction of exposure to personnel is achieved by the installation of engineered mitigation measures and the radon concentration is brought to below the IRR17 Action Level. Where radon concentrations are 300 Bq m <sup>-3</sup> (averaged annually) or greater, and no mitigation measures are planned, steps must be taken to reduce the exposure of employees, usually through limited occupancy of the area.
Maintenance of radiation engineering controls	✓	Any engineering control (installed remediation, mitigation) designed to restrict exposure to personnel must be properly maintained, and, where appropriate, undergo thorough examinations and tests at suitable intervals. Those with mechanical parts will require regular maintenance and checks.
Contingency plans	✗	Contingency plans for radon exposure are not normally required.

Requirement	Applicable	Comments
Designated areas	see comment	<p>Where radon monitoring shows the radiation dose to employees is likely to exceed 6 mSv a year* (and no engineered mitigation measures are planned) a controlled area should be designated.</p> <p>Where radon monitoring shows the radiation dose to employees is likely to exceed 1 mSv a year* (and no engineered mitigation measures are planned) a supervised area should be designated.</p> <p>Both of these measures come with additional administrative and practical requirements. Seek RPA advice for further information.</p> <p>*Annual dose can be calculated by multiplying the seasonally corrected (annually averaged) radon concentration in Bq m<sup>-3</sup> by 3.18x10<sup>-6</sup> and then by the occupancy of the area in question in hours. The RPA should be consulted in respect to dose calculations.</p>
Monitoring	✓	The measurement of radon concentration is the currently accepted way to assess the radon exposure of persons occupying the workplace or area. Where ground level and below ground level workplaces are in radon affected areas, radon monitoring must be carried out. Radon monitoring must also be implemented to assess the effectiveness of any remediation carried out.
Training for users	✓	Information and instruction are required. The RPA will advise if individuals are also required to undertake the Dstl WPS (Radon) course.
Local orders	✓	Local orders are required to detail any control measures to protect against exposure to radon and the radiation safety management organisation. These should, if applicable, describe any engineered controls present, their maintenance, any monitoring regime in place, any administrative control (e.g. occupancy limitation) and detail the RSO, WPS (Radon) and their contact details.
Appointed person	✓	An RPS is required in areas designated as controlled or supervised – the RPA will advise. Where an RPS is not required, and the radon gas concentration is equal to or greater than 300 Bq m <sup>-3</sup> (averaged annually), a WPS (Radon) is to be appointed.
Personal dosimetry	✓	The RPA will advise if personal radon dosimetry is required.
Classified persons	✓	If personnel are likely to be incur greater than 6 mSv of radiation dose in a year, they should be a classified person. The RPA will advise.
Reporting procedures	✓	Certain incidents are required to be reported to MOD authorities. Reporting to external regulatory authorities may also be required. See Chapter 14 for details.

\*JSP 392, unless otherwise stated

## RPA contact details

31. The Dstl RPA contact details are:

Radiation Sciences Group, DSTL Chemical, Biological & Radiological Division, Institute of Naval Medicine, Alverstoke, Hants PO12 2DL  
DIO Project Technical Authority: Dee Emerson  
Email: [dmemerson@dstl.gov.uk](mailto:dmemerson@dstl.gov.uk)  
Telephone: 01980 951958

Dstl Approved Dosimetry Service,  
Deputy Head Dstl ADS: David Andrews  
Email: [ADSEnquiries@dstl.gov.uk](mailto:ADSEnquiries@dstl.gov.uk)  
Telephone: 01980 954280

## Radiation Safety Arrangements for Protection Against Radon Exposure in Residential Accommodation

### Introduction

1. The Housing Health and Safety Rating System (HHSRS) Regulations 2005 requires landlords to assess all potential hazards that exist in their properties which includes the risk from radon. Therefore MOD, as a landlord, is required to assess the risk, and instigate measures to mitigate this risk if the levels found to equal or exceed the Action Level (estimated average of  $200\text{Bq m}^{-3}$  over a calendar year), see Table A1 below. Radon affected areas (RAA) in the UK have been identified by Public Health England (PHE) in conjunction with the British Geological Survey (BGS) and a map has been produced to help make an assessment of a property's risk.
2. If the site is deemed to be in a radon affected area, radon monitoring will be required to determine the actual radon concentration in the particular premises. There are two types of accommodation on the MOD estate: Single Living Accommodation (SLA) and Service Family Accommodation (SFA). The requirements of The Building Regulations (2010) apply to new build residential accommodation.
3. Defence Infrastructure Organisation (DIO) is responsible for ensuring compliance with the Regulations in respect to radon. DIO appoint a Maintenance Management Organisation (MMO) to manage the radon programme for SFA. The MMO will subcontract to specialist radon companies to provide the radon monitoring and remediation programmes. The MMO will have their own appointed Radiation Protection Advisor as will the subcontractors.
4. Radon management in SLA is currently provided by the respective site Top Level Budget holder e.g. RAF, Navy Command, Army, Joint Forces Command etc., through their appointed Radiation Protection Advisor, Dstl. Where engineered remediation is required, a specialist radon contractor must be contracted to assess the requirement and carry out the work.

### Measurement of Radon

5. SFA located within RAA (as defined by the PHE/BGS data): DIO's MMO will monitor all properties included in their contract. Currently, SFA monitoring is carried out by a DIO-appointed contractor who install two radon monitors per property (one on the ground floor and one on the first floor (assuming conventional two storey property)).
6. The DIO contractor is to inform the householders, in writing, in advance of the requirement to place radon monitoring.
7. SLA (also includes SLAM, PFI etc.), and blocks of flats. Dstl will provide support in assessing the requirement for radon monitoring. If required, undertaking radon monitoring of at least 10-20% of ground floor rooms will provide adequate coverage for each building.

## **Monitoring Duration**

8. The detectors will typically be installed for a three-month period; the detectors will be located and fixed in accordance with the advice provided by the RPA.

## **Results and Subsequent Actions**

9. The results will be presented in terms of Becquerel per cubic metre ( $\text{Bq m}^{-3}$ ), to the RPA. The RPA will assess the requirement for future actions and remediation against the data in Table A1 and in paragraphs 13-18 below.

10. The MMO will provide DIO and their RPA with monitoring results after each monitoring tranche that will include the name of the site address e.g. RAF Brize Norton and the street name. A separate report will be provided to DIO and their RPA for properties who have results above the action levels and therefore require the installation of engineered remediation. This report should detail the type of engineered remediation being installed e.g. sump / fan etc., the site and the street name.

11. The householder (SFA) is to be provided with written confirmation of the monitoring results and information on any requirement for remediation measures on request to the MMO.

12. Results for SLA monitoring will be provided by Dstl to the workplace POC together with advice on any required course of actions in respect to remediation.

## **Actions and Remediation Measures**

13. PHE guidance states that where engineered remediation is required, this should be such that the radon levels are reduced to below  $100 \text{ Bq/m}^{-3}$ .

14. For properties with annual average radon levels between  $100$  &  $150 \text{ Bq/m}^{-3}$  the situation should be kept under review in consultation with specialist advice (e.g. RPA). Re-monitoring should take place every five years.

15. For properties where one or both of the results are between  $150 \text{ Bq/m}^{-3}$  and  $200 \text{ Bq/m}^{-3}$  re-monitoring will take place at three yearly intervals.

16. For any property where one or more of the results is equal to or exceeds  $200 \text{ Bq/m}^{-3}$  (Action Level), engineered remediation will be installed. The exact nature of the remediation will be determined on a case-by-case basis (considerations such as the type, construction, location of the property and cost will be made) by a specialist radon contractor. Re-monitoring will be undertaken immediately after the installation is complete to ensure that the remediation is effective.

17. The MMO has pre-approval from DIO to implement engineered remediation without further consultation. Where engineered remediation is required for SLA, this requirement will be taken up by the respective site POC through the normal funding process.

18. Properties with installed engineered remediation should be tested on an annual basis to ensure the mitigation measures continue to be effective.

Table A1 Actions required following radon monitoring results (based on 3-month environmental monitoring)

Estimated annual average radon level	above 199	Consult specialist advice (e.g. RPA) Restrict exposure (e.g. install remediation measures). Consider monitoring radon levels until remediation measures are installed.
Estimated annual average radon level	$\geq 150$ , but $< 200$	Consult specialist advice (e.g. RPA). Consider installing remedial measures. Re-monitor dwellings on a three-yearly basis Consider immediate action to reduce exposure, e.g. simple ventilation.
Estimated annual average radon level	100-150	Keep situation under review, consider retesting on a five-yearly basis.

### Internal Management of Radon Monitoring Programme

19. Regular meetings between DIO, DIO's RPA, the MMO and their RPA should take place at a minimum of twice a year to discuss the planned programme of work, dosimetry results, remediation and any other related issues.