



**EPA PROTOCOL FOR THE MEASUREMENT OF
RADON IN HOMES & WORKPLACES
May 2019**

1. THE MEASUREMENT OF RADON IN HOMES

1. Scope

To ensure the results of radon gas measurements for a **home** can be compared with the national Reference Level (200 Bq/m³) and to ensure the measurements are carried out in a consistent manner across the country, the radon gas concentration must be determined in accordance with the Environmental Protection Agency's measurement protocol as set out here.

This protocol also includes detector handling and measurement procedures, the application of seasonal adjustment factors and required report contents.

2. Detector handling procedures for the measurement of radon in homes

To ensure that the radon measurement is as accurate as possible it is important that:

- Detectors are ordered as needed so they are not stored for long periods of time before use. Due to the effects of aging and fading, detectors should not be stored for more than one year
- Detectors should be stored in a freezer (where necessary) until dispatch to customers
- A unique identifier should be applied to each detector to ensure traceability
- Detectors returned by the customer should retain their unique identifiers and include details of the start and end exposure dates.

3. Procedures for the measurement of radon in homes

The radon gas concentration shall be measured using a detector capable of integrating the radon exposure continuously over a period of not less than 3 months. Suitable devices include, but are not limited to CR-39¹ alpha track diffusion radon gas detectors.

It is important to ensure that customers place the detectors as follows:

- One detector should be placed in a bedroom that is in regular use. The second detector should be placed in a living room.
- Avoid placing the detector beside window sills, radiators, fireplaces, television sets or inside any object.
- Detectors should be placed at least one metre above the floor for example, on top of a dressing table, coffee table or bedside locker.
- Detectors should be left in place for no less than 3 months and no greater than 12 months.
- The date on which the detectors are placed and removed and the placement location for each detector should be recorded.

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Seasonal adjustment of radon concentrations

Where the measurement period is less than 12 months, the seasonal adjustment factors set out in Appendix 1 shall be applied to determine the seasonally adjusted radon concentration.

The seasonally adjusted average radon concentration for a home is the mean of the seasonally adjusted radon concentrations for the main living area and the main bedroom.

This seasonally adjusted average radon concentration is then compared to the national reference level of 200 Bq/m³.

4. Communicating the results of a radon in homes measurement

Where a laboratory is issuing test results to a supplier, ideally, these results should be issued in the form of a pdf. This will facilitate traceability of results.

The test report issued to the customer² shall include the following:

- The name of the testing service and the person responsible for issuing the report, including their signature.
- The name of the customer, or contact as appropriate
- The full address of the building tested
- The report date
- The unique identifier for each detector which is traceable to the original results
- A report reference
- The measurement period (start and end date)
- The actual measured radon gas concentration at the two measurement locations (bedroom and living room) in becquerels per cubic metre (Bq/m³).
- Where the measurement period is less than 12 months, the seasonally adjusted annual average radon gas concentration for the home in becquerels per cubic metre (Bq/m³) should be included.
- The results should be compared with the national reference level for homes of 200 Bq/m³.
- A suggested template for the above is given in Appendix 2.

Where the results of the test exceed the national Reference Level:

(a) For results between 200 and 800 Bq/m³ the following additional information shall be included with the test report:

- A link to or copy of the EPA booklet [Understanding Radon Remediation](#).
- A link to or list of registered radon remediation services as provided on www.radon.ie
- A link to or copy of the leaflet [radon and your health](#).

² Note that a pdf of results may be emailed to the customer

- Advice to follow up remediation work with an independent test provided by a registered measurement service as provided on www.radon.ie. This is to confirm that the radon levels have been successfully reduced to be below the national reference level of 200 Bq/m³ for homes.
 - Advice to carry out a retest within 5 years of the remediation work to confirm that the radon levels continue to be below 200 Bq/m³ for homes.
 - The customer can also be referred to the Radon Advice Section of the EPA for further information.
- (b) For results between 800 and 2,000 Bq/m³ in addition to (a), the customer should be called by phone to discuss the findings and ensure that the risks associated with their results are understood, specifically:
- Ensure placement of detectors within the home was correct. For example, placement of detectors in a cupboard can result in elevated results that are not present in the living areas.
 - Outline health risks associated with exposure to radon including the increased risks to smokers.
 - Outline options for reducing the radon levels in the home.
 - Outline grant assistance that may be available from the [Housing Section of the Local Authority](#).
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- (c) For results exceeding 2,000 Bq/m³, in addition to (a) and (b) the Radon Advice Section of the EPA should be notified immediately of the anonymised results. This should include the individual results, the measurement date and the townland/ village/ town.

2. MEASUREMENT OF RADON IN WORKPLACES

1. Scope and legislative requirements

To ensure that the results of radon gas measurements in a **workplace** can be compared with the national reference level of 300 Bq/m³ for workplaces and meet the requirements of [S.I. No. 30 of 2019](#) measurements shall be determined in accordance with the Environmental Protection Agency's measurement protocol as set out here.

This protocol includes detector placement requirements such as the number of detectors required and the selection of measurement locations within the workplace. It also includes handling and measurement procedures, the application of seasonal adjustment factors and required report contents.

It should be noted that some workplaces, such as prisons, nursing homes, psychiatric hospitals and live-in training units, also have residential areas. For those areas that are clearly residential the reference level for homes of 200 Bq/m³ is applicable, while for those areas that are clearly workplaces the statutory reference level of 300 Bq/m³ applies. For areas where there is a doubt as to whether they are residential or workplaces, for example a communal area in a prison or nursing home, the 200 Bq/m³ reference level is recommended. Further advice regarding this is set out in the EPA's guidance document: "Advice on setting a reference level for radon concentrations in long stay institutions" available at: www.radon.ie.

Article 66 of [S.I. No. 30 of 2019](#) places a general duty on employers in high radon areas to test for radon. If radon concentrations above 300 Bq/m³ are found, employers are required to take remedial action or implement an on-going system of radiation protection relevant for Existing Exposure Situations. Implementing such a system is onerous and is only needed when remedial work has failed to reduce the radon concentrations and therefore the risk needs to be managed.

Radon remediation is usually straightforward therefore this is the preferred and simplest course of action to demonstrate compliance with the regulations.

The requirements of Article 66 may be summarised as follows:

- The **national reference level** for indoor radon concentrations in air in workplaces is **300 Bq/m³** as measured in accordance with this protocol
- An employer or self-employed person who is responsible for a workplace **shall measure the indoor radon concentrations** where the workplace is:
 - (a) **underground**, including mines and show caves;
 - (b) on the ground floor or basement level **in high radon areas**
 - (c) one identified by the EPA as being liable to have radon concentrations above 300 Bq/m³ when measured in accordance with this protocol.

- Measurements **shall be carried out in accordance with guidelines** issued by the Environmental Protection Agency
- Where the results of a radon measurement **exceed the national reference level** of 300 Bq/m³, **remedial measures shall be taken** to reduce the radon concentrations to below this national reference level.
- Following remedial work **further radon measurements** should be carried out as soon as practicable **to determine whether the radon concentrations have been reduced to below the national reference level.**
- **The remedial work and the follow up radon measurements should be completed within 12 months of the date of the original radon measurement that first identified radon concentrations above 300 Bq/m³.**
- If following remedial works radon concentrations remain above 300 Bq/m³ the employer or self-employed person shall:
 - (a) **notify the Environmental Protection Agency**
 - (b) **Assess the radiation dose to workers and update this assessment in accordance with guidelines as may be issued by the EPA.**
- If radiation doses to workers are in excess of 6 mSv per year, the employer shall apply the relevant provisions for an Planned Exposure Situation. Further details regarding the relevant provision governing Planned Exposure Situations are available from the EPA.

[S.I. No. 30 of 2019](#) defines a “high radon area” as an area where more than 10% of homes in that area are predicted to have radon concentrations above the national reference level for homes of 200 Bq/m³.

Radon in the workplace also falls within the scope of the Safety, Health and Welfare at Work Act, 2005, regulated by the Health and Safety Authority (HSA). This Act requires employers to identify the hazards at the workplace, assess the risk to health and safety from these hazards and put in place measures to eliminate or reduce the risk. The HSA has stated that where radon gas is identified as a hazard in the workplace the employer has a duty, as with any other hazard, to assess the risk and eliminate or reduce that risk.

Workplaces in areas not designated as “high radon areas” are not required to carry out radon measurements unless there are specific reasons as to why high radon concentrations might be expected. However, it is important to note that workplaces with radon concentrations above the national reference level can be found in any area of the country. All employers in areas not designated as a “high radon areas” are urged to take a pro-active approach and consider having radon measurements made. It should be noted that outdoor workplaces would not be expected to have elevated radon concentrations and therefore no radon measurements are required. This applies to workers in the agricultural, fishing, construction, transport and other outdoor industries.

2. Detector handling procedures for the measurement of radon in workplaces

To ensure that the radon measurement is as accurate as possible it is important that:

- Detectors are ordered as needed so they are not stored for long periods of time before use. Due to the effects of aging and fading, detectors should not be stored for more than one year.
- Detectors should be stored in a freezer (where necessary) until dispatch to customers.
- A unique identifier should be applied to each detector to ensure traceability.
- Detectors returned by the customer should retain their unique identifiers and include details of the start and end exposure dates.

3. Procedures for the measurement of radon in workplaces

The radon gas concentration shall be measured using a detector capable of integrating the radon exposure continuously over a period of not less than 3 months. Suitable devices include, but are not limited to CR-39³ alpha track diffusion radon gas detectors. These measurements must be carried out by a measurement service registered with the EPA.

Number and location of detectors

- (a) The main entry route for radon into buildings is through cracks and gaps in the floor. Consequently, basement and ground floor rooms are likely to have the highest radon concentrations. Normally, therefore, a workplace survey should be made in workspaces located on the ground floor and in basement levels, where these are occupied.
- (b) It is not necessary to carry out measurements in areas such as corridors, washrooms, toilets, etc. which are unoccupied or occupied infrequently. As a general rule, an infrequently occupied area is one where an individual is unlikely to spend more than 100 hours per year of their working time.
- (c) The recommended number of detectors per workplace is based on the number of offices or on the floor area to be surveyed and on the workplace type. Recommended measurement densities are set out in Table 1 for different workplace types.
- (d) Where a workplace consists of a number of different work area types, each type should be considered separately for the purpose of determining the number of detectors. For example, in a factory the number of detectors to be placed in the offices should be determined by the number of offices on the ground floor or basement areas, while the number of detectors to be placed in warehouses or workshops should be determined independently on the basis of the area of these workspaces (Table 1).
- (e) Radon concentrations can vary significantly between adjacent buildings. Radon concentrations in an adjacent or adjoining building should not, therefore, be taken as indicative of the concentrations in a particular workspace. Therefore, where a

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workplace is divided over a number of adjacent buildings it is necessary that each building be surveyed separately.

- (f) In the case of multi-storey buildings occupied by more than one employer, measurements made on the ground and basement levels would normally be sufficient for assessing compliance with the reference level for all workplaces in the building.
- (g) Where different employers are responsible for different floors of a multi-storey building, employers whose staff are located on upper floors should have radon measurements carried out unless they can confirm that the radon concentrations in the ground floor and basement workplaces do not exceed the reference level.

Seasonal adjustment of radon concentrations

The measurement period should be at least 3 months and less than 12 months (to avoid ageing and fading – see section 2). The results of each workplace measurement is seasonally adjusted using the seasonal adjustment factors set out in Appendix 1. This gives the seasonally adjusted radon concentration for each workplace measured.

This seasonally adjusted radon concentration is then compared to the national reference level for workplaces of 300 Bq/m³.

Note: individual measurements in workplaces and schools are not averaged. If any one measurement is greater than 300 Bq/m³ then remediation is needed. This is different to homes where it is the seasonally adjusted average that is compared to the Reference Level for radon in homes, 200 Bq/m³.

Table 1. Survey Strategies for Above Ground Workplaces

Workplace type	Number of detectors	Examples
Office-type accommodation	One detector per individual office	Banks, schools, government premises, professional practices
Open plan office, and retail or workshop up to 1000 m ² , also public access areas	One per 200 m ²	Administrative and call centres, light industry, hotel foyers
Areas from 1,000 to 5,000 m ²	One per 400 m ²	Warehouses, small supermarkets
Very large areas of several thousand m ²	One for each distinct area with obviously different environmental conditions. Not less than 1 per 500 m ²	Large manufacturing or process plants, large warehouses
Basements	One in each separate room, section or area irrespective of size, even if infrequently used (but greater than 100 hours/year occupancy).	Bank vaults, mechanical and/or electrical control centres

Placement of detectors in workplaces

When placing detectors, the following should be noted:

- (a) Care should be taken to select locations where detectors are exposed to air that is representative of that in the workplace. Detectors should not be placed in enclosed spaces such as cupboards, or in direct proximity to a source of fresh air such as an air intake fan, permanent background ventilation or a frequently opened window. It is preferable to avoid placing detectors beside heaters or radiators.
- (b) Detectors should be placed at least one metre above the floor.
- (c) Detector locations should provide a reasonable degree of security, as it is important that detectors are not moved or interfered with during the measurement period. It is recommended that detectors be clearly labelled and that the purpose of the survey should be explained to all workers (including cleaning staff).
- (d) Detectors should be left in place for no less than 3 months and no greater than 12 months.
- (e) The date on which the detectors are placed and removed and the placement location for each detector should be recorded.

4. Communicating the results of radon in workplace measurements

The test report issued to the customer⁴ shall include the following:

- The name of the testing service and the person responsible for issuing the report, including their signature.
- The name of the customer, or contact as appropriate
- The full address of the building tested
- The report date
- The unique identifier for each detector which is traceable to the original results
- A report reference
- The measurement period (start and end date)
- Where the measurement period is less than 12 months, the seasonally adjusted radon gas concentration for each of the measurements in becquerels per cubic metre (Bq/m³) should be included.
- The results for each workplace measured should be compared with the national reference level for workplaces of 300 Bq/m³.
- A suggested template for the above is given in Appendix 3.

⁴ Note that a pdf of results may be emailed to the customer

Where the results of the test exceed the national Reference Level:

(a) For results between 300 and 2,600 Bq/m³ the following additional information shall be included with the test report:

- A link to or copy of the EPA booklet [Understanding Radon Remediation](#).
- A link to or list of registered radon remediation services as provided on www.radon.ie
- A link to or copy of the leaflet [radon and your health](#).
- Information about the requirement to follow up remediation work to confirm that the radon levels have been successfully reduced to be below the national reference level of 300 Bq/m³ for workplaces.
- Advice to carry out a retest within 5 years of the remediation work to confirm that the radon levels continue to be below 300 Bq/m³.
- The customer can also be referred to the Radon Advice Section of the EPA for further information.

(b) For results between 2,600 and 6,500 Bq/m³ in addition to (a), the customer should be called by phone to discuss the findings and ensure that the risks associated with their results are understood, specifically:

- Outline health risks associated with exposure to radon including the increased risks to smokers.
- Outline options for reducing the radon levels in the workplace.
- The customer can also be referred to the Radon Advice Section of the EPA for further information.

(c) For results exceeding 6,500 Bq/m³, in addition to (a) and (b) the Radiation Protection Regulation Section of the EPA should be notified immediately of the results.

Appendix 1
Seasonal Adjustment Factors Suitable for Use in Irish Homes and Workplaces

Table 2. One month seasonal adjustment factors for radon measurements in Irish homes and workplaces.

January	1.16
February	1.16
March	1.12
April	1.05
May	0.96
June	0.89
July	0.85
August	0.84
September	0.88
October	0.96
November	1.04
December	1.11

Seasonal adjustment is carried out for all measurements that are carried out over less than 12 months.

1. The Application of Seasonal Adjustment Factors to Home Measurements

This carried out by:

- (a) **Averaging the monthly correction factors** given above for the measurement period. For example, where the measurement period covers the months of April, May and June, the seasonal adjustment factor is calculated as follows:

$$\frac{1.05 + 0.96 + 0.89}{3} = 0.97$$

- (b) **Applying the seasonal adjustment factor** of 0.97 to each of the individual measurements in the bedroom and living area. For example, measurements with the following results:

Bedroom: 150 Bq/m³
 Living Area: 210 Bq/m³

Resulting in seasonally adjusted results of

Bedroom: 150/ 0.97 = 154 Bq/m³
 Living Area: 210/ 0.97 = 216 Bq/m³

(c) **Averaging these seasonally adjusted results:**

$$(154+216)/2 = 185 \text{ Bq/m}^3$$

It is this seasonally adjusted average radon concentration that is compared to the national reference level for homes of 200 Bq/m³.

The Application of Seasonal Adjustment Factors to Workplace Measurements

This is carried out by:

(a) **Averaging the monthly correction factors** given above for the measurement period. For example, where the measurement period covers the months of December, January and February, the seasonal adjustment factor is calculated as follows:

$$\frac{1.11 + 1.16 + 1.16}{3} = 1.14$$

(b) **Applying the seasonal adjustment factor** of 1.14 to the individual room measurements. For example, measurements with the following results:

Office A:	280 Bq/m ³
Office B:	350 Bq/m ³
Office C:	220 Bq/m ³

Resulting in seasonally adjusted results of

Office A:	280/ 1.14 =	246 Bq/m³
Office B:	330/ 1.14 =	290 Bq/m³
Office C:	220/ 1.14 =	193 Bq/m³

It is these seasonally adjusted radon concentrations that are compared to the national reference level for workplaces of 300 Bq/m³.

Note that these results are not averaged in the way that home measurements are.

Note:

1. Only the results of home radon measurements made in accordance with this protocol can be compared to the national reference level for homes of 200 Bq/m³.
2. Only the results of workplace radon measurements made in accordance with this protocol can be compared to the national reference level for workplaces of 300 Bq/m³.
3. Where measurements are carried out for periods greater than three months, the seasonal adjustment factors for each of the measurement months should be used to calculate the average seasonal adjustment factor.
4. Where the measurement includes 15 or more days of a month, the seasonal adjustment factor for that month should be included in calculating the average, otherwise it should not be included.
5. The above seasonal adjustment factors are derived from the following:
 - a. Burke, O., Long, S., Murphy, P., Organo, C., Fenton, D. and Colgan, P.A. Estimation of seasonal correction factors through Fourier decomposition analysis – a new model for indoor radon levels in Irish homes. *Journal of Radiological Protection*. *J. Radiol. Prot.* 30 (2010) 433-443.
 - b. Kennedy, C and Murphy, P. Seasonal correction factors for Irish workplaces and schools. University College Dublin Report 2016/2017.

Appendix 2
Suggested Template for Radon in Homes Measurement Report

Name of Radon Measurement Service

Radon Measurement Report

Name and address of customer		Measurement address
Report date	Report Reference	Measurement period
Detector Number	Location	Seasonally adjusted radon concentration (Bq/m ³)
	Living area	
	Bedroom	
Seasonally adjusted average radon concentration		

Since the seasonally adjusted average radon concentration in air in this home is below the national reference level of 200 Bq/m³, the **Radon Measurement Service** advises that no further action is necessary.

OR (as appropriate)

Since the seasonally adjusted average radon concentration in air in this home exceeds the national reference level of 200 Bq/m³, the **Radon Measurement Service** advises that you consider remediation. Further information on radon remediation may be found in the EPA booklet [Understanding Radon Remediation](#). The EPA provides a list of registered radon remediation services on www.radon.ie More information about radon and health may be found in the EPA leaflet [radon and your health](#). Further advice is available from the EPA's Radon Advice Section.

Report issued by: Signature of person responsible for issuing report

Name of person responsible for issuing report

Appendix 3
Suggested Template for Radon in Workplaces Measurement Report

Name of Radon Measurement Service

Radon Measurement Report

Name and address of customer		Measurement address
Report date	Report Reference	Measurement period
Detector Number	Location	Seasonally adjusted radon concentration (Bq/m ³)
	Location 1 description	
	Location 2 description	
	Location 3 description etc	

Since the seasonally adjusted radon concentration in air in each location of this workplace are below the national reference level of 300 Bq/m³, the **Radon Measurement Service** advises that no further action is necessary. You are advised to retain this report as evidence that you have monitored your workplace for radon.

OR (as appropriate)

Since the seasonally adjusted radon concentration in air in one or more locations in this workplace exceeds the national reference level of 300 Bq/m³, the **Radon Measurement Service** advises that this workplace be remediated by an EPA registered remediation service to reduce radon concentrations to below 300 Bq/m³.

Information on radon remediation methods may be found in the EPA booklet [Understanding Radon Remediation](#). The EPA provides a list of registered radon remediation services on www.radon.ie More information about radon and health may be found in the EPA leaflet [radon and your health](#). Further information and guidance on Radon in Workplaces is available from the EPA's Radiation Protection Regulation Section.

Report issued by: Signature of person responsible for issuing report

Name of person responsible for issuing report

Appendix 4
Glossary of Terms

Building Type	Term
Home	<i>Seasonally adjusted radon concentration:</i> An individual radon measurement result of less than one year that has been adjusted for the time of year that the measurement was carried out. (See Appendix 1 for worked examples)
	<i>Seasonally adjusted average radon concentration:</i> The average of the two seasonally adjusted radon concentrations measured in a home. (See Appendix 1 for worked examples)
Workplace or School	<p><i>Seasonally adjusted radon concentration:</i> An individual radon measurement result of less than one year that has been adjusted for the time of year that the measurement was carried out. (See Appendix 1 for worked examples)</p> <p>Note: workplace and school measurements are not averaged in the way that home measurements are.</p>
Planned Exposure Situation	<p>An exposure situation that arises from the planned operation of a radiation source or from a human activity which alters exposure pathways, so as to cause the exposure or potential exposure of people or the environment.</p> <p>Planned Exposure Situations normally arise in practices where Radioactive substances or X-ray equipment are used.</p>