

# Validation Scheme for Organisations Making Measurements of Radon in Dwellings: 2008 Revision

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## ABSTRACT

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A revised scheme is described for the approval of suppliers of passive radon detectors for the measurement of radon in dwellings and the interpretation of results. This 'Validation Scheme' applies to long-term measurements for estimating the annual average of the radon concentration indoors and comparing it to the prevailing Action Level. The scheme deals with the physical and administrative requirements for validation and specifies the procedures to be followed and the performance to be achieved. Suppliers engaged in such work are invited to participate.



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## **EXECUTIVE SUMMARY**

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This document sets out a validation scheme by which suppliers of passive radon detectors can demonstrate competence in the measurement of radon levels in UK dwellings and in the interpretation of those results. The scheme includes a review of the procedures used by each supplier, to ensure that an adequate quality system is in place, together with practical tests that assess their ability to measure radon by exposing detectors to known quantities of radon.

The aim of the validation scheme is not only to ensure good laboratory practice, and to address issues such as data protection, record keeping and dealing with complaints from customers.

Because radon levels are highly variable on all timescales, the scheme only applies to long term measurements, those of three months or longer. Shorter measurements, and especially those of less than a month, may be useful for screening purposes where time is short, but give a less accurate assessment of the annual average radon concentration, and are not covered by this scheme.



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# 1 INTRODUCTION

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**1.1** Long-term measurement of average radon concentration using passive radon detectors, such as etched-track devices, is the most suitable technique for identifying dwellings where the radon concentration is above the Action Level recommended by the HPA and the government (NRPB, 1990). Discretionary grants may be available from local government towards the costs of remedial work to reduce high radon concentrations.

**1.2** To enable an adequate quality of measurement, HPA-RPD operates the validation scheme described in this document. Local government have been requested by the government departments with responsibility for radon in dwellings to give favourable consideration only to grant applications supported by monitoring results from laboratories successfully participating in the scheme.

**1.3** Short-term measurement techniques are not generally an appropriate basis for advice to householders on whether to install remedial measures, and are not covered by this validation scheme. HPA-RPD offers calibration and testing of such techniques as circumstances require.

**1.4** Application of the criteria below for successful validation is intended to provide suppliers and clients with confidence in the quality of the radon measurements and in the ability of laboratories to provide a sound interpretation of the measurements.

**1.5** This document replaces NRPB-M1140, *Validation Scheme for Laboratories Making Measurements of Radon in Dwellings: 2000 Revision* (Miles and Howarth, 2000). Changes have been made for four principal reasons:

- (1) to clarify what documentation is required for validation,
- (2) to clarify the performance test criteria for measurements to determine whether dwellings are above the radon Action Level,
- (3) to allow the use of temperature correction factors as an alternative to the use of seasonal correction factors,
- (4) to clarify the division of responsibilities in cases where the supplier of validated measurements obtains radon detectors from a different organisation.

**1.6** Suppliers that offer validated measurements in dwellings are also likely to have the facilities and expertise to provide useful data to employers about radon levels in workplaces. It should be noted, however, that the method of interpretation of measurements for workplaces differs from that in houses and that the results will not be sufficient to advise employers fully or unequivocally about the effect of legislation on their activities. Validated measurements can however provide a general indication as to whether the Ionising Radiations Regulations 1999 (Health and Safety Executive, 1999) are likely to apply in a workplace. Where the radon concentrations measured mean that the Regulations are found to apply, employers are required to make their own

arrangements for compliance. Detailed advice on the application and effect of the Regulations is available from the Health and Safety Executive.

## **2 EXPLANATION OF TERMS**

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### **2.1 Client**

A client is any person or organisation for whom the Supplier carries out radon monitoring.

### **2.2 Supplier**

A Supplier is a party seeking to be validated, or already validated, for the measurement and interpretation of the results of radon exposure in the air of dwellings. The Supplier may be an independent organisation, part of another organisation, or a supplier of detectors originating with a third party.

### **2.3 Processing Laboratory**

A Processing Laboratory is an organisation that produces and analyses detectors used for the measurement of radon in air. A Processing Laboratory may be part of the same organisation as the Supplier, or a separate entity.

### **2.4 Performance Tests**

Performance tests are those laid down by the Validation Authority as necessary to determine that the Processing Laboratory meets the criteria of acceptable uncertainty in determining the radon exposure in dwellings, both on initial application for validation and on a continuing basis to maintain validated status.

### **2.5 Radon**

Radon in this document refers to the principal isotope, radon-222, of the gas.

### **2.6 Radon concentration**

The radon concentration is the activity of radon per unit volume of air, expressed as Bq m<sup>-3</sup> (becquerels per cubic metre).

### **2.7 Radon exposure**

Radon exposure is the time-integrated concentration of radon, expressed in kBq h m<sup>-3</sup>.

### **2.8 Validation**

Validation is formal recognition by the Validation Authority that the supplier is competent to carry out measurements of radon exposure in dwellings and also competent to interpret such measurements in a manner consistent with the national policy on radon in dwellings (NRPB, 1990).

### **2.9 Validation Authority**

The Validation Authority will be the Radiation Protection Division of the Health Protection Agency (HPA-RPD), acting in support of the national programme for reducing

exposure to radon. It will operate the validation scheme and determine whether a Supplier meets the validation requirements.

### **3 APPLICATION FOR VALIDATION**

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- 3.1** Applications should be made to the Validation Authority and should be accompanied by a Validation Manual giving details of the devices and procedures for which validation is sought and information concerning the Supplier's organisation, resources, personnel and methods. This manual will be resubmitted every January.
- 3.2** The Validation Authority will maintain confidentiality about the information disclosed in the Validation Manual, and will not use it for any purpose other than validation of the laboratory.
- 3.3** A Supplier shall be Validated for the provision of radon measurements using a particular type of detector with appropriate processing and reporting procedures if:
- (a) the Validation Manual is deemed acceptable by the Validation Authority;
  - (b) the initial performance tests are completed successfully;
  - (c) the Supplier participates satisfactorily in continuing performance tests.
- 3.4** Where a Supplier has been Validated for the provision of measurements based on the use of a particular device and set of procedures and wishes to introduce other measurements based on a different device or procedures, the Laboratory must not claim to be Validated for the new measurements until an appropriate application has been submitted to and successfully processed by the Validation Authority.
- 3.5** Where a Supplier provides radon detectors for the purpose of short term screening measurements, that is measurements with a duration of less than three months, the Supplier shall not imply, directly or otherwise, that it is validated for the provision of such measurements.
- 3.6** Where a Laboratory provides radon measurements for purposes other than the determination of radon concentrations in dwellings or using procedures other than those for which successful application has been made to the Validation Authority, the Supplier shall not imply, directly or otherwise, that it is validated for the provision of such measurements.
- 3.7** The Validation Authority shall maintain an up-to-date list of validated suppliers which will be available on demand and published in an appropriate manner, including on the HPA website.
- 3.8** The Validation Authority will make such charges as are necessary to cover the cost of operating the Validation Scheme and performing and administering the tests. These may be varied from time to time.

## **4 VALIDATION MANUAL**

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A model manual is given in Appendix A. The manual shall contain, for each type of detector, method of assessment and application for which Validation is sought:

- 4.1** A brief description of the radon detector.
- 4.2** A brief description of the procedure for assessing radon exposure of the detector.
- 4.3** Details of the intended application of the measurement.
- 4.4** Point-by-point confirmation that the laboratory meets the requirements 5.1 - 13.3 with documentary evidence where appropriate.

## **5 ORGANISATION AND MANAGEMENT**

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**5.1** The Processing Laboratory manager and their appointed deputy, responsible for the day-to-day operation of the radon monitoring service, should be suitably qualified and experienced. In particular, these persons should understand: the physical principles on which the monitoring device is based and its limitations; the requirements for handling the devices before and after deployment; the requirements for processing and for maintaining the stability of the processing equipment; the interpretation of the results obtained.

**5.2** The Processing Laboratory and Supplier shall be organised so that members of staff shall not be subject to any influence that might adversely affect their judgement or the outcome of their work. Commercial involvement with organisations undertaking radon remedial or preventive work shall be made clear to the Client.

**5.3** Technical responsibility for preparing and signing radon measurement reports shall be given only to members of staff recognised as suitably competent by the Validation Authority.

## **6 STAFF RECORDS**

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**6.1** For each task to be performed, the Supplier or Processing Laboratory shall use competent members of staff who have an appropriate combination of academic qualifications, training, skill and experience. The use of persons undergoing training is acceptable provided they are supervised and that the number of staff undergoing training does not adversely affect the quality of the work undertaken.

**6.2** The Supplier and Processing Laboratory shall have documented policy and procedures to ensure that existing and new staff have and maintain the relevant competence in radon measurements.

**6.3** The Supplier and Processing Laboratory shall maintain up-to-date records of the relevant competence of all such members of staff, which shall be available to the Supplier or Processing Laboratory manager and, on request, to the Validation Authority.

## **7 QUALITY SYSTEMS**

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**7.1** All aspects of relevant operations and responsibilities shall be documented to the extent necessary to ensure the adequate and consistent quality of the measurement procedures. Members of staff shall have ready access to all documents on the handling of monitoring devices prior to issue, on receipt after exposure, and during processing.

**7.2** All amendments to such documents shall be subject to management control, and the Supplier or Processing Laboratory shall have procedures clearly defining responsibility for the generation and distribution of amendments. Alterations to existing documents shall be clearly legible and indelible.

**7.3** The Supplier or Processing Laboratory shall have procedures to be followed where departures from documented policies and procedures, for any reason, have been found. Where such departures may have affected the quality of reported results of radon measurements, these procedures shall require that work is halted immediately and all necessary investigations and corrective actions are undertaken before further work is performed.

**7.4** Departure from documented policies and procedures may be permitted where it can be shown that there are valid technical reasons for doing so and the quality of measurements is not adversely affected. The justification for the departure, with endorsement by management, shall be noted in the relevant records.

## **8 PROCESSING LABORATORY EQUIPMENT AND ENVIRONMENT**

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**8.1** The Processing Laboratory shall utilise suitable equipment for all stages in the radon measurement process, including data storage and manipulation.

**8.2** Equipment shall be protected as far as possible from deterioration and abuse. Where applicable, the manufacturer's instructions shall be available and followed. All equipment in service shall be checked regularly to ensure operation is within specification, and records shall be kept.

**8.3** Each item of equipment used by the Processing Laboratory shall, where appropriate, be uniquely identified.

**8.4** For equipment requiring calibration, a record shall be kept comprising a full up-to-date history of performance, including calibration data.

**8.5** Any item of equipment which suffers damage from mishandling, or gives suspect results, or malfunctions, or is shown by tests to be defective or unfit for use, shall be immediately withdrawn from service. It shall be segregated and prominently marked and shall not be returned to service until it has been repaired, recommissioned and re-calibrated as appropriate.

**8.6** Where computers or other automated equipment are used for the collection, manipulation, recording, reporting, storage or retrieval of measurement data, the Processing Laboratory shall ensure that, where applicable, the preceding requirements of this section are met. The Processing Laboratory shall, wherever possible, ensure that computer software is documented and tested before use.

**8.7** The Processing Laboratory should be based in accommodation which is not subject to adverse influences of a mechanical, thermal, or other nature, and should have concentrations of radon in air that are sufficiently low as to cause negligible adventitious exposure of detectors while in the accommodation. Environmental control must be sufficiently stringent to ensure that no equipment or detector material is subject to conditions likely to affect its performance.

## **9 HANDLING OF DETECTORS**

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**9.1** The Supplier shall have an effective documented system for identifying radon detectors: it shall be designed and operated so as to ensure that detectors cannot be confused physically or in records or other documents.

**9.2** The identification systems shall permit ready cross-reference to be made between the identifiers for each detector and any other identifier associated with the use of that detector (such as the Client's identifier, order number, or report number).

**9.3** Each detector shall be assigned a unique identifying number. Labelling or some equivalent method shall be used to ensure that the assigned identifier is associated with the detector until the final report of the result is issued.

**9.4** Where detectors are re-usable, each use of the detector should have a unique identifier which distinguishes it and the particular issue number.

**9.5** Upon receipt of a detector for processing, any departure from its normal condition shall be noted and recorded. Where there are any resulting doubts as to the validity of the result, the Client must be informed in a clear and unambiguous manner.

## **10 MEASUREMENT PROTOCOL**

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**10.1** The Processing Laboratory and Supplier shall follow a measurement protocol appropriate to the purpose of estimating the annual average of the radon gas concentration for comparison with the Action Level.

**10.2** All validated measurements shall take place over a period of at least three months using one detector in the main living area of the dwelling and one in an occupied bedroom.

**10.3** Measurements to test the efficacy of remedial measures shall take place in the same living area and occupied bedroom as the measurements made before the installation of remedial measures.

**10.4** The dynamic range of the detector shall cover at least the range 50 - 400 Bq m<sup>-3</sup> for a three-month exposure. If the dynamic range of the detector is too small to cover the range 50 - 1000 Bq m<sup>-3</sup> for a three-month exposure, the Supplier may report to the Client that the radon concentration is greater than a particular value. It shall then offer a repeat measurement to determine the concentration with greater accuracy. This repeat measurement shall be carried out at the expense of the Supplier.

**10.5** The detector shall be of a design that excludes radon decay products.

**10.6** The householder shall be provided with appropriate instructions for placing and returning the detectors. Suggested model placement instructions are provided in Appendix B.

## **11 REPORTING PROCEDURES**

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**11.1** All radon concentrations must be reported in units of becquerels per cubic metre of air (Bq m<sup>-3</sup>).

**11.2** The estimate of the annual average radon concentration in a dwelling shall be calculated as follows:

- a Take a weighted mean of living room and bedroom radon concentrations, using weights of 0.45 and 0.55 respectively.
- b If, due to loss of a detector, only one result is available for a house, the house average may be estimated by multiplying a living room result by 0.83, or by dividing a bedroom result by 0.83. In this event, the householder should be informed that estimating on the basis of a single result is less accurate than estimating on the basis of a pair of results.
- c Calculate the estimated annual mean radon concentration in the dwelling. This may be done by multiplying the weighted mean concentration by the appropriate seasonal correction factor from Table 1. Alternatively, if the mean outdoor temperature during the measurement is known, the estimated annual mean radon concentration may be calculated by multiplying the weighted mean concentration by the factor  $1/(1.645 - 0.063 \times \text{mean outdoor temperature})$  (Miles, 1988). Other methods of calculating the estimated annual mean radon concentration may be used, provided that they are based on published data.

**11.3** The Supplier shall advise the Client of the estimated annual average radon concentration. If it so desires, the Supplier may also report the average concentrations

of radon actually measured, but should clearly distinguish these from the foregoing parameter.

**11.4** The advice to be offered to the Client about the course to consider on the basis of the estimated annual average radon concentration shall be in accordance with that shown in Table 3.

**11.5** In cases where the measurement is not intended to estimate the annual mean radon concentration in a dwelling (and is therefore not described as validated), other values may be reported instead, such as the actual mean radon concentration during the measurement, or the estimated annual maximum radon concentration (see Table 2).

## **12 RECORDS OF OPERATION**

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**12.1** The Processing Laboratory and Supplier shall have and maintain a systematic and documented record of all information of relevance to the validated radon measurements it makes. The records shall be designed and maintained so as to facilitate identification of any sources of error.

**12.2** The Processing Laboratory and Supplier must maintain an appropriate degree of confidentiality, and where necessary, comply with relevant data protection legislation.

**12.3** The record for each detector shall include:

- (a) the complete address, with postcode, of the dwelling in which it was placed, including the name of the occupier;
- (b) the location within the dwelling at which the detector was placed;
- (c) the date of start of the measurement;
- (d) the duration of the measurement;
- (e) the radon exposure in  $\text{kBq h m}^{-3}$ , or the average radon concentration during the period of measurement in  $\text{Bq m}^{-3}$ .

**12.4** The record for each dwelling shall also include, with an indication of the methods of derivation:

- (a) the occupancy-weighted average radon concentration;
- (b) the seasonally-corrected or temperature-corrected value of the foregoing parameter.

**12.5** To facilitate the maintenance of a national database on radon in dwellings, the Supplier shall provide to the Validation Authority a copy of the weighted and corrected result for each dwelling, which shall be identified only by the postcode. Previous results in the same dwelling shall also be identified. These results shall be supplied in the form of a list containing all results which were reported to clients within a calendar year. The

list for a given year shall be supplied no later than the last day of January of the following year.

## **13 COMPLAINTS AND ANOMALIES**

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**13.1** The Supplier shall have documented policy and procedures for the resolution of complaints from Clients. A record shall be maintained of all complaints and of the actions taken by the Supplier.

**13.2** Where a complaint or any other circumstance raises doubt about compliance with any element of this validation scheme, the matter must be promptly investigated. Should the investigation indicate that the Supplier or Processing Laboratory had been operating in an invalid manner, it must endeavour to correct the matter, if appropriate, and undergo a continuing performance test as soon as possible.

**13.3** If the need arises, the Validation Authority shall be given reasonable access to the record of complaints.

## **14 PERFORMANCE TESTS**

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**14.1** In the case of an initial performance test, the Supplier shall submit thirty-five detectors to the Validation Authority. Five of these will be stored in a radon-free atmosphere and the remainder subjected to radon exposures in the range 100 to 2000 kBq h m<sup>-3</sup>. The detectors will be returned to the Supplier for processing and the Supplier shall report the calculated exposure for each detector to the Validation Authority for assessment.

**14.2** For a continuing performance test, the Supplier shall submit fifteen detectors to the Validation Authority. Five of these will be stored in a low radon atmosphere and the remainder subjected to radon exposures in the range 200 to 1000 kBq h m<sup>-3</sup>. The detectors will be returned to the Supplier for processing and the Supplier shall report the calculated exposure for each individual detector to the Validation Authority for assessment. The interval between continuing performance tests shall not exceed six months.

**14.3** If a Supplier uses a detector with a dynamic range of response too small to cover the range of exposures given in 14.1 and 14.2, it may report results as greater than a particular value. It shall then supply to the Validating Authority replacement detectors for retesting.

**14.4** The Validating Authority shall estimate radon exposures in performance tests using techniques traceable to national standards. The exposures so estimated shall be designated 'nominal exposures'.

**14.5** The performance test shall consist of two parts. A Supplier shall be deemed to have passed the first part of a performance test if the total uncertainty for exposed detectors does not exceed the following limits:

- (a) 50% in the exposure range 100 to 200 kBq h m<sup>-3</sup>;
- (b) 15% in the exposure range 200 to 1000 kBq h m<sup>-3</sup>;
- (c) 50% in the exposure range 1000 to 2000 kBq h m<sup>-3</sup>.

These limits have been set to require maximum accuracy at exposures equivalent to a three month exposure at both the domestic and occupational Action Levels.

Total uncertainty for the purposes of validation is defined in terms of the mean percentage difference between the reported result and the nominal radon exposure (D), and the percentage standard deviation of the reported result (S), using the following equation:

$$\text{Total uncertainty} = \sqrt{D^2 + S^2}$$

A Supplier shall be deemed to have passed the second part of the performance test if the mean integrated exposure of the transit detectors is less than 45 kBq h m<sup>-3</sup>. This is equivalent to a three month exposure at the average UK radon level of 20 Bq m<sup>-3</sup>, and 10% of the UK Action Level.

Should a validated Supplier fail a continuing performance test, it must discover the causes of failure and rectify them as soon as possible. If it does not submit to and successfully complete an initial performance test within 30 days of being notified of its failure in the continuing performance test, it must halt the issuing and processing of detectors until it has successfully completed an initial performance test or indicate that measurements are not validated.

## 15 REFERENCES

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- Health and Safety Executive (1999): The Ionising Radiations Regulations 1999, Statutory Instrument 1999 No. 3232, HMSO, London.
- Miles, JCH (1998) "Mapping radon-prone areas by lognormal modelling of house radon data". Health Physics 74, 370-378.
- Miles and Howarth, (2000). "Validation Scheme for Laboratories Making Measurements of Radon in Dwellings: 2000 Revision" NRPB-M1140.
- NRPB (1990). Board Statement on limitation of human exposure to radon in houses. Docs NRPB, Vol 1, No. 1, 15-16.

**TABLE 1 Seasonal correction factors for derivation of annual average radon concentration, as used for domestic measurements**

| Start month | Duration (months): |      |      |      |      |      |      |      |      |      |      |
|-------------|--------------------|------|------|------|------|------|------|------|------|------|------|
|             | 1                  | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   |
| Jan         | 0.68               | 0.70 | 0.74 | 0.78 | 0.84 | 0.90 | 0.97 | 1.03 | 1.05 | 1.05 | 1.03 |
| Feb         | 0.73               | 0.77 | 0.83 | 0.89 | 0.96 | 1.05 | 1.11 | 1.13 | 1.12 | 1.09 | 1.05 |
| Mar         | 0.81               | 0.88 | 0.96 | 1.04 | 1.15 | 1.20 | 1.23 | 1.20 | 1.15 | 1.10 | 1.04 |
| Apr         | 0.97               | 1.06 | 1.15 | 1.29 | 1.34 | 1.33 | 1.28 | 1.21 | 1.14 | 1.07 | 1.02 |
| May         | 1.18               | 1.27 | 1.45 | 1.49 | 1.45 | 1.35 | 1.26 | 1.17 | 1.08 | 1.03 | 1.01 |
| Jun         | 1.40               | 1.64 | 1.64 | 1.54 | 1.40 | 1.27 | 1.16 | 1.07 | 1.02 | 0.99 | 0.99 |
| Jul         | 2.00               | 1.79 | 1.59 | 1.40 | 1.25 | 1.14 | 1.04 | 0.98 | 0.96 | 0.96 | 0.98 |
| Aug         | 1.63               | 1.45 | 1.28 | 1.14 | 1.04 | 0.96 | 0.92 | 0.90 | 0.91 | 0.93 | 0.96 |
| Sep         | 1.31               | 1.16 | 1.04 | 0.96 | 0.89 | 0.85 | 0.85 | 0.86 | 0.89 | 0.92 | 0.97 |
| Oct         | 1.03               | 0.94 | 0.88 | 0.82 | 0.80 | 0.80 | 0.82 | 0.85 | 0.89 | 0.94 | 0.98 |
| Nov         | 0.87               | 0.82 | 0.76 | 0.76 | 0.77 | 0.79 | 0.83 | 0.88 | 0.94 | 0.98 | 1.00 |
| Dec         | 0.77               | 0.72 | 0.73 | 0.74 | 0.78 | 0.83 | 0.88 | 0.94 | 0.99 | 1.02 | 1.02 |

To derive the seasonally corrected average multiply the occupancy weighted mean for a dwelling by one of these factors based on the month in which the measurement started and the duration of the measurement, rounded to the nearest month.

**Table 2 Seasonal correction factors for derivation of annual maximum radon concentration, where this is required.**

| Start month | Duration (months): |      |      |      |      |      |      |      |      |      |      |
|-------------|--------------------|------|------|------|------|------|------|------|------|------|------|
|             | 1                  | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   |
| Jan         | 1.00               | 1.03 | 1.08 | 1.15 | 1.23 | 1.32 | 1.43 | 1.51 | 1.55 | 1.54 | 1.51 |
| Feb         | 1.07               | 1.13 | 1.21 | 1.31 | 1.41 | 1.54 | 1.63 | 1.66 | 1.64 | 1.60 | 1.54 |
| Mar         | 1.19               | 1.30 | 1.42 | 1.54 | 1.70 | 1.78 | 1.80 | 1.76 | 1.69 | 1.61 | 1.53 |
| Apr         | 1.43               | 1.56 | 1.70 | 1.90 | 1.98 | 1.97 | 1.89 | 1.78 | 1.68 | 1.57 | 1.51 |
| May         | 1.74               | 1.87 | 2.13 | 2.19 | 2.13 | 2.00 | 1.85 | 1.71 | 1.59 | 1.51 | 1.48 |
| Jun         | 2.06               | 2.41 | 2.40 | 2.26 | 2.06 | 1.87 | 1.71 | 1.57 | 1.49 | 1.46 | 1.45 |
| Jul         | 2.94               | 2.63 | 2.35 | 2.06 | 1.84 | 1.67 | 1.52 | 1.44 | 1.41 | 1.41 | 1.44 |
| Aug         | 2.37               | 2.13 | 1.88 | 1.68 | 1.53 | 1.41 | 1.35 | 1.33 | 1.34 | 1.37 | 1.41 |
| Sep         | 1.93               | 1.70 | 1.53 | 1.41 | 1.30 | 1.26 | 1.25 | 1.27 | 1.31 | 1.35 | 1.42 |
| Oct         | 1.51               | 1.39 | 1.29 | 1.20 | 1.17 | 1.18 | 1.21 | 1.26 | 1.31 | 1.39 | 1.44 |
| Nov         | 1.28               | 1.20 | 1.13 | 1.11 | 1.13 | 1.17 | 1.23 | 1.29 | 1.38 | 1.44 | 1.47 |
| Dec         | 1.13               | 1.07 | 1.07 | 1.09 | 1.15 | 1.22 | 1.29 | 1.39 | 1.46 | 1.49 | 1.49 |

These factors are used to derive the maximum (January) radon concentration. For each measurement, multiply the result by the factor obtained from the start month and measurement duration, rounded to the nearest month.

**TABLE 3 Advice to be given to householders on the basis of the estimated annual average radon concentration**

| Estimated annual average radon concentration | Advice  |
|--|---|
| Less than 100 Bq m <sup>-3</sup>             | Remedial measures not required                                  |
| 100 - 200 Bq m <sup>-3</sup>                 | Consider installing remedial measures                           |
| 200 - 1500 Bq m <sup>-3</sup>                | Install remedial measures                                       |
| More than 1500 Bq m <sup>-3</sup>            | Install remedial measures; contact HPA-RPD for specific advice. |

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## APPENDIX A

### Model validation manual

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#### A1 RADON VALIDATION SCHEME MANUAL FOR SUPPLIER X

This document describes how Supplier X meets the requirements for validation of Suppliers making measurements of radon in dwellings as set out in HPA-RPD-Rxxx.

Paragraph numbering follows that in the memorandum.

Appendices attached:

|     |                                     |                   |
|-----|-------------------------------------|-------------------|
| 1.  | Description of detector and its use | Published paper   |
| 2.  | Preparation and handling            | protocol QA AB/16 |
| 3.  | Acceptance criteria                 | protocol QA AB/17 |
| 4.  | Production                          | protocol QA AB/18 |
| 5.  | Reception, dismantling              | protocol QA AB/19 |
| 6.  | Etching                             | protocol QA AB/20 |
| 7.  | Counting                            | protocol QA AB/21 |
| 8.  | Calibration                         | protocol QA AB/22 |
| 9.  | Calculation and reporting           | protocol QA AB/23 |
| 10. | Records of competence of staff      | protocol QA AB/24 |
| 11. | Complaints and anomalies            | protocol QA AB/25 |

Description of detector: See appendix 1.

Description of procedure for assessing radon exposure: See appendix 1.

Intended application: Measurements of radon in dwellings and workplaces.

Paragraph 5: Organisation and management

5.1 Standard procedures ensure that this requirement is met. The laboratory manager is A, and the deputy is B.

5.2 Standard procedures ensure that this requirement is met.

5.3 Standard procedures ensure that this requirement is met.

#### Paragraph 6: Staff records

6.1 Standard procedures ensure that this requirement is met.

6.2 The appendices attached fully document the procedures used. Staff are required to follow these procedures. New staff are trained in the procedures before handling detectors used in dwellings.

6.3 Standard procedures ensure that this requirement is met. See appendix 10.

#### Paragraph 7. Quality systems

7.1 Standard procedures ensure that this requirement is met. See appendices.

7.2 Standard procedures ensure that this requirement is met.

7.3 Standard procedures ensure that this requirement is met. Departures from standard procedures are reported to the manager or his deputy for a decision on action.

7.4 Standard procedures ensure that this requirement is met.

#### Paragraph 8. Laboratory equipment and environment

8.1 Standard procedures ensure that this requirement is met.

8.2 Standard procedures ensure that this requirement is met.

8.3 Standard procedures ensure that this requirement is met.

8.4 Standard procedures ensure that this requirement is met.

8.5 Standard procedures ensure that this requirement is met.

8.6 Standard procedures ensure that this requirement is met.

8.7 Standard procedures ensure that this requirement is met.

#### Paragraph 9. Handling of detectors

9.1 Standard procedures ensure that this requirement is met. Detectors are uniquely coded with a hole code, and records of their placement are kept on a computer database which is backed up each day.

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- 9.2 Standard procedures ensure that this requirement is met.
  - 9.3 Standard procedures ensure that this requirement is met.
  - 9.4 Detectors are not re-used.
  - 9.5 Standard procedures ensure that this requirement is met.

Paragraph 10. Measurement protocol

- 10.1 Standard procedures ensure that this requirement is met.
- 10.2 Standard procedures ensure that this requirement is met.
- 10.3 Standard procedures ensure that this requirement is met.
- 10.4 Standard procedures ensure that this requirement is met.

Paragraph 11. Reporting procedures

- 11.1 Standard procedures ensure that this requirement is met.
- 11.2 Standard procedures ensure that this requirement is met.
- 11.3 Standard procedures ensure that this requirement is met.
- 11.4 Standard procedures ensure that this requirement is met.

Paragraph 12. Records of operation

- 12.1 Standard procedures ensure that this requirement is met.
- 12.2 Standard procedures ensure that this requirement is met.
- 12.3 Standard procedures ensure that this requirement is met.
- 12.4 Standard procedures ensure that this requirement is met.
- 12.5 Standard procedures ensure that this requirement is met.

Paragraph 13. Complaints and anomalies

- 13.1 Standard procedures ensure that this requirement is met. See appendix 11.
- 13.2 Standard procedures ensure that this requirement is met.
- 13.3 Standard procedures ensure that this requirement is met.

Date

(Signed) Manager

## APPENDIX B

### Model placement instructions for radon detectors in dwellings

- Don't open the detector casing or remove any of the labels, as the results may be affected.
- Write on the record card the date that you placed the detectors.
- Store the record card in a safe place.
- Put the 'Living area' detector in the room that is most used during the day. It can be placed on a shelf or on (but not in) a piece of furniture. If possible, choose a position near an interior wall.
- Don't place the detectors on the floor, in direct sunlight, in draughts, near sources of heat or inside any object. Avoid window sills, radiators, fireplaces, televisions, and other electrical items that may get warm.
- Select a bedroom that is used regularly and follow the same procedure for the 'Bedroom' detector.
- If you are planning any major building works, or can't comply with the placement instructions for any reason, please do not try to store the detectors. Contact your supplier immediately for advice.
- The detectors are made of harmless materials, but do place them out of reach of small children and pets.
- The detectors stay in place for around three months. Make a note of the date three months from now and the locations of the detectors, and place it on a notice board or calendar to remind you to return the detectors.
- After the three month exposure period, remove the detectors and write the date on the record card. Return the detectors and record card immediately using the packaging provided. The result will normally be available within X weeks of the detectors being returned.