INTERNATIONAL STANDARD

ISO 11665-8

First edition
2012-11-01

Measurement of radioactivity in the environment — Air: radon-222 —

Part 8: Methodologies for initial and additional investigations in buildings

Mesurage de la radioactivité dans l'environnement — Air: radon 222 —

Partie 8: Méthodologies appliquées aux investigations initiales et complémentaires dans les bâtiments

Reference number
ISO 11665-8:2012(E)

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 11665-8 was prepared by Technical Committee ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 2, *Radiological protection*.

ISO 11665 consists of the following parts, under the general title *Measurement of radioactivity in the environment — Air: radon-222*:

— *Part 1: Origins of radon and its short-lived decay products and associated measurement methods*

— *Part 2: Integrated measurement method for determining average potential alpha energy concentration of its short-lived decay products*

— *Part 3: Spot measurement method of the potential alpha energy concentration of its short-lived decay products*

— *Part 4: Integrated measurement method for determining average activity concentration using passive sampling and delayed analysis*

— *Part 5: Continuous measurement method of the activity concentration*

— *Part 6: Spot measurement method of the activity concentration*

— *Part 7: Accumulation method for estimating surface exhalation rate*

— *Part 8: Methodologies for initial and additional investigations in buildings*

The following parts are under preparation:

— *Part 9: Method for determining exhalation rate of dense building materials*

— *Part 10: Determination of diffusion coefficient in waterproof materials using activity concentration measurement*

— *Part 11: Test method for soil gas*

Introduction

Radon isotopes 222 and 220 are radioactive gases produced by the disintegration of radium isotopes 226, and 224, which are decay products of uranium-238 and thorium-232 respectively, and are all found in the earth's crust. Solid elements, also radioactive, followed by stable lead are produced by radon disintegration [1].

Radon is today considered to be the main source of human exposure to natural radiation. The UNSCEAR (2008) report [2] suggests that, at the worldwide level, radon accounts for around 52 % of global average exposure to natural radiation. The radiological impact of isotope 222 (48 %) is far more significant than isotope 220 (4 %), while isotope 219 is considered negligible.

The International Cancer Research Centre (ICRC) of the World Health Organization (WHO) has recognized radon as a lung carcinogen in humans since 1987.

In this part of ISO 11665, the term radon refers to its isotope 222.

Radon activity concentration can vary from one to multiple orders of magnitude over time and space. Exposure to radon and its decay products varies tremendously from one area to another, as it depends on the amount of radon emitted by the soil, on the weather conditions, and on the degree of containment in the areas where individuals are exposed [3].

Radon activity concentration is usually higher in buildings than in the outside atmosphere due to the lower air renewal rates. The more the ventilation is reduced, the greater the accumulation of radon in buildings. The underlying soil is usually the dominant source of radon in buildings. Building materials, outside air, tap water and even city gas can also contribute to increasing radon activity concentration.

Radon enters buildings mainly via a convection mechanism, the so-called "stack effect" that is due to a difference in air temperature between the inside and the outside of the building, which generates a difference in pressure between the air in the building and the air contained in the underlying soil. The radon activity concentration depends on the architecture, equipment (chimney, mechanical ventilation systems, etc.) and the environmental parameters of the building (temperature, pressure, etc.) and on the occupants' lifestyle.

Radon activity concentrations vary inside buildings by several tens of becquerels per cubic metre to several hundreds of becquerels per cubic metre [4]. Activity concentration can be as high as several thousands of becquerels per cubic metre in very confined spaces.

The assessment of the radon activity concentration of the atmosphere in a building is based on a step-by-step procedure with two measuring stages: the initial investigation, to estimate the annual average value of the radon activity concentration in the building, and, when needed, additional investigations.

When it is decided that the radon activity concentration in a building has to be reduced, mitigation techniques will be adapted to each individual case [5][6][7]. The impact of the mitigation will be assessed using new radon measurements in the building.

NOTE The origin of radon-222 and its short-lived decay products in the atmospheric environment are described generally in ISO 11665-1 together with measurement methods.

Measurement of radioactivity in the environment — Air: radon-222 —

Part 8: Methodologies for initial and additional investigations in buildings

1 Scope

This part of ISO 11665 specifies requirements for the determination of the activity concentration of radon in all types of buildings. The buildings can be single family houses, public buildings, industrial buildings, underground buildings, etc.

This part of ISO 11665 describes the measurement methods used to assess, during the initial investigation phase, the average annual activity concentration of radon in buildings. It also deals with investigations needed to identify the source, entry routes and transfer pathways of the radon in the building (additional investigations).

Finally, this part of ISO 11665 outlines the applicable requirements for the immediate post-mitigation testing of the implemented mitigation techniques, monitoring of their effectiveness and testing of the sustainability of the building's behaviour towards radon.

This part of ISO 11665 does not address the technical building diagnostic or the prescription of mitigation work.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6707-1, *Building and civil engineering — Vocabulary — Part 1: General terms*

ISO 11665-1, *Measurement of radioactivity in the environment — Air: radon-222 — Part 1: Origins of radon and its short-lived decay products and associated measurement methods*

ISO 11665-4, *Measurement of radioactivity in the environment — Air: radon-222 — Part 4: Integrated measurement method for determining average activity concentration using passive sampling and delayed analysis*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11665-1 and ISO 6707-1 and the following apply.

3.1.1
additional investigations
stage of actions, including measurements, when identifying the sources of radon and its entry routes and transfer pathways in a building

3.1.2
building
anything that is constructed or results from construction operations, usually partially or totally enclosed and designed to stand permanently in one place, and whose main purpose is to provide shelter for its occupants and contents

NOTE 1 In this part of ISO 11665, a building is considered as underground if its roof is partly or entirely underground (see Figure B.1).

NOTE 2 The buried levels of a building are those with their ceiling entirely below the ground level (see Figure B.2).

3.1.3
building mapping
spatial presentation of measurement results showing the distribution of radon activity concentration data in the different spaces of the building in order to identify those where radon activity concentration is the highest

NOTE The measurements carried out for the building mapping are representative of the prevailing conditions at the time of sampling and thus cannot be used to establish the annual average activity concentrations.

3.1.4
homogeneous zone
zone including one or more adjacent volumes inside the building that share identical or very close characteristics (type of walls, floors, basement, foundations, building level, water supply, water usage patterns, ventilation, openings, temperature, etc.) with a homogeneous activity concentration of radon

NOTE 1 A homogeneous zone is defined based on the following main criteria:

— same type of soil-building interface;

— same ventilation conditions (no ventilation system, natural ventilation, mechanical ventilation, etc.);

— same temperature level.

NOTE 2 In cases where water can be a potential source of radon, the following additional criteria apply:

— same mode of water supply (direct, indirect, continuous, recycled);

— same type of water usage patterns (washing, showering, therapeutic care).

3.1.5
initial investigation
first stage of actions, including measurements, when determining the annual average activity concentration of radon in a building

3.1.6
mitigation techniques
technical means implemented in an existing building in order to reduce the activity concentration of radon

3.1.7
occupied volume
volume regularly occupied with a residence time justifying an interest with regard to the radon exposure risk

EXAMPLE Living-room, workshop, office, classroom, etc.

3.1.8
radon entry routes
passages and vectors (air or water) that permit radon to penetrate the building

NOTE Radon does not enter uniformly across the entire envelope of the building. The preferred entry routes are cracks in the soil-building interface, piping runs, etc.

3.1.9
radon source
origin of radon present in the building

NOTE The main source of radon in buildings is usually the underlying soil. In some cases, building materials, the outdoor air, water (inflow water, supply water, thermal water, etc.) and even city gas are additional sources that can increase the radon activity concentration.

3.1.10
radon transfer pathways
passages and vectors (air or water) that permit radon to move from one volume in the building to another

NOTE Radon transfer pathways commonly include piping runs, staircases, doorways, etc.

3.1.11
soil-building interface
contact surface between the soil and the building

NOTE The soil-building interface can, for example, be formed by:

— a beaten-earth floor;

— an earthen floor;

— a slab or floor on a crawl space, technical space, basement or cellar;

— buried or semi-buried walls in contact with the ground;

— etc.

3.1.12
technical building diagnostic
investigation operations conducted to identify the causes of the presence of radon detected in a building during the initial investigation, and to provide the data and information needed to choose appropriate long-lasting mitigation techniques

3.1.13
value of interest
pre-fixed value of the annual average radon activity concentration, from which actions shall be taken to reduce the annual average activity concentration in a building [8]

NOTE The values of interest, also referred to as reference levels, are fixed by regulations issued by the competent administrative national authority or agreed contractually by the parties involved.

3.1.14
volume
closed space in a building

EXAMPLE Room, corridor, box room, workshop, office, classroom, crawl space, cellar, etc.

3.2 Symbols

For the purposes of this document, the symbols given in ISO 11665-1 and the following apply.

$\overline{C}$ average annual radon activity concentration, in becquerels per cubic metre

$\overline{C}_\mathrm{I}$ value of interest of the radon activity concentration, in becquerels per cubic metre

4 Organization of the measuring stages

The assessment of the radon activity concentration of the atmosphere in a building is based on a step-by-step procedure with different measuring stages:

— The presence of radon in a building shall be demonstrated through an initial investigation in accordance with the requirements described in Clause 5. The aim of this stage is to obtain measurement data with which to assess the annual average activity concentration of radon that will be compared to the value of interest.

— If the initial investigation demonstrates that the radon activity concentration is lower than any values of interest, the sustainability of the building's behaviour towards radon is monitored in accordance with the requirements set out in Clause 9. If changes in the building can alter its sustainability, the initial investigation shall be performed again in accordance with the requirements set out in Clause 5.

— If the initial investigation demonstrates that the radon activity concentration is higher than any values of interest, investigations shall be performed in order to identify the causes of the presence of radon at this level in the building (technical building diagnostic, etc.). Depending on the type of building involved, and particularly for large-footprint buildings with complex structure configurations, additional investigations may be carried out to help identify the sources of radon (soil, building materials and water) and its entry routes and transfer pathways in the building. These additional investigations shall be carried out in accordance with the requirements set out in Clause 6.

— If mitigation techniques (simple actions such as power on ventilation, building works, etc.) are implemented, immediate post-mitigation testing may be performed using short-term radon measurements that are not representative of the annual average value (Clause 7). The effectiveness and the sustainability of these mitigation techniques shall be monitored in accordance with the requirements set out in Clauses 8 and 9.

NOTE An example of the organization of the different stages is given in Annex A.

5 Initial investigations

5.1 Objective

The aim of the initial investigation is to determine whether a building or part of a building shows an annual average value of radon activity concentration above any values of interest.

5.2 Methodology followed during the initial investigation

The initial investigation shall be performed following the time sequence described below:

— selection of measuring devices;

— location of the measuring points in the building;

— installation and removal of measuring devices;

— processing of measuring devices;

— data analysis of measurement results obtained for each homogeneous zone;

— initial investigation report drafting.

5.3 Selection of measuring devices

The measurement method used to assess the annual average activity concentration shall be the long-term integrated measurement method described in ISO 11665-4.

Several types of measuring device complying with the requirements of ISO 11665-4 may be used during the initial investigation. However, to facilitate the data analysis and the interpretation of the measurement results, the same type of measuring device shall be used per building.

For a specific atmosphere with a high variable equilibrium factor (dusty atmosphere, high humidity, highly ventilated, etc.), a passive measuring device in so-called “closed configuration” shall be used.

5.4 Location of the measuring points

5.4.1 General

The installation of the measuring devices follows a three-stage protocol which determines:

— the homogeneous zones in the building under investigation;

— the number of devices per homogeneous zone required to take the representative measurements;

— the locations of the measuring points in the homogeneous zones.

5.4.2 Determination and selection of the homogeneous zones

Homogeneous zones are determined from the lowest floor upwards in order to progressively select a total surface of occupied homogeneous zone that is at least equal to the ground level area of the building. This approach is expected to select the homogeneous zones with the highest activity concentration of radon.

This approach is performed following two steps:

— The determination of homogeneous zones is based on:

  — the following main criteria:

    — same type of soil-building interface;

    — same ventilation conditions (no ventilation system, natural ventilation, mechanical ventilation, etc.);

    — same temperature level;

  — the following additional criteria when water can be a potential source of radon:

    — same mode of water supply (direct, indirect, continuous, recycled);

    — same type of water usage patterns (washing, showering, therapeutic care).

— The selection of homogeneous zones shall comprise at least one occupied room.

In specific cases where specific sources other than soil (water and/or building materials) have been identified, this approach is performed for each building floor concerned.

For buried levels of a building, this approach is performed for each floor that is below ground-level, and each homogeneous zone that is occupied is selected.

For underground buildings, this approach is performed for each building floor.

NOTE 1 In the case of large buildings or buildings with a complex structure, the determination of the homogeneous zones requires a visit to these premises.

NOTE 2 In the case of single family houses, the determination of the homogeneous zones is usually simple as each floor constitutes a homogeneous zone.

5.4.3 Number of measuring devices to be installed

At least one measuring device shall be installed in each selected homogeneous zone, with a minimum of two devices per building.

In the case of large homogeneous zones, one device is installed for every 200 m^2.

5.4.4 Installation of measuring devices

The measuring device(s) shall be installed in an occupied volume of the building for each selected homogeneous zone. Areas not representative of the exposure conditions shall be avoided, particularly entrances, cellars, garages, pathways and attics.

The use of the premises shall dictate the choice of location. Normal conditions of use and occupation of the premises shall not be altered during the measurement.

The measuring device shall be placed on a free surface between 1 m and 2 m above the ground, under the following conditions:

— the chosen position is selected with a free space consistent with the detection volume of the measuring device to ensure a measurement representative of the atmosphere of the homogeneous zone; if the walls are made of building materials with a high content of thorium, a free space of at least 20 cm shall be left around the sensor to avoid the influence of the thoron's exhalation from the walls [9];

— the measuring device shall be placed away from:

  — a source of heat (radiator, chimney, electrical equipment, television, direct sunlight, etc.);

  — a water supply outlet (risk of splashing) or a condensation point-source;

  — a source of fat projection;

— the chosen position is such that the installation conditions should not be modified during measuring for whatever reason (books falling, engineers working, curiosity, etc.) and thus recommendations shall be made to occupants to prevent damaging the exposure conditions of the measuring device. The measuring device shall be made secure during its exposure.

5.5 Installation and removal of the measuring devices

To approach the annual average value of the radon activity concentration in a building and in order not to underestimate the average value of the radon activity concentration:

— at least half of the measurement period has to be in the winter or during the heating season;

— the measuring devices shall operate for at least two months. The measurements shall be performed during a period when the number of consecutive days during which the premises are unoccupied does not exceed 20 % of the adopted period. Premises that are not occupied for extended periods are excluded as the radon can accumulate due to the lack of air renewal.

The device shall be configured to "measure" when it is installed (see recommendations from measuring device manufacturers) and shall be configured to "stop" when it is removed.

The times (date and hour) of the installation and removal phases shall be recorded.

In all circumstances, the measuring conditions shall be documented correctly in the test report (see Annex B).

NOTE 1 It is important for the occupants to carry on with their normal daily routine during the measuring process.

NOTE 2 In the event of seasonally related inoccupancy, the measurement period shall be adjusted to the period of occupancy.

5.6 Processing of the measuring devices

Refer to the recommendations of ISO 11665-4 and the manufacturer's recommendations on processing the measuring devices. The value of the average radon activity concentration is expressed in becquerels per cubic metre ($Bq \cdot m^{-3}$) and is accompanied by its expanded uncertainty with an expansion factor, k, equal to 2.

The expression of the average radon activity concentration is inseparable from the sampling duration and the period of year at which the measurement is performed. It is also undissociable from the occupant's lifestyle, measuring point levels (basement, ground floor, upper floors) or ventilation characteristics (normal building ventilation kept stable).

The results can be expressed in a similar format to that shown in Annex C.

5.7 Data analysis

The measurement results are analysed for each of the homogeneous zones selected in the building.

The data analysis shall take into account the following criteria:

— the influence quantities described in ISO 11665-4;

— modifications of the building leading to a modification of the criteria used to define the homogeneous zone during measuring/sampling (work, ventilation, etc.);

— changes in occupation of the premises during measuring (removals, change of use, absence, etc.);

— the sampling duration.

When the measurement results obtained within the same homogeneous zone show a disparity lower than the uncertainties, the average radon activity concentration is calculated. This average value, expressed in becquerels per cubic metre, without the associated uncertainty, is attributed to the homogeneous zone (see Annex D). This value is compared with the values of interest.

When the distribution of the measurement results obtained within the same homogeneous zone is higher than the uncertainties, a root cause analysis of the distribution range shall be led:

— if the cause is due to measuring devices, then integrated measurements shall be repeated under the conditions set out in 5.4;

— if the cause is due to methodology factors, then integrated measurements shall be repeated under the conditions set out in 5.4, or the highest value recorded, ignoring its measurement uncertainty, is selected and attributed to the homogeneous zone (see Annex D). This value is compared with the values of interest.

NOTE For a given homogeneous zone, if the set of measurements includes results that are below the limit of detection, then the value attributed to this homogeneous zone is determined based solely on the significant results.

5.8 Initial investigation report

The initial investigation report ensures the traceability of the measurements and checks their conformity.

The initial investigation report shall contain the following information:

a) reference to this part of ISO 11665 and, if appropriate, to the regulatory texts governing the situation;

b) date of the report;

c) sampling times: start and end time (date and hour);

d) sampling locations;

e) measurement method (integrated);

f) identification of the type of sensor;

g) test report according to ISO 11665-4; the test report shall be attached to the initial investigation report;

h) analysis of the measurement results;

i) conclusion with a comparative analysis of the value attributed to each selected homogeneous zone against the pre-defined values of interest.

Complementary information can be provided, such as the following:

— identification of the person requesting the initial investigation;

— references of the author(s) of the report;

— references of the persons who were in charge of the initial investigation;

— report reference code, written on every page of the report, with page numbering featuring the total number of pages; when a new version of the initial investigation report needs to be issued, it shall be given a new reference code or a new version index, and shall include a statement naming the original report it replaces;

— description of the methodology followed;

— justification of the determination and the selection of the homogeneous zones;

— justification of the number of measuring devices installed;

— a schematic drawing of the building, marking locations and references of the measuring devices installed;

— description of the measurement conditions.

6 Additional investigations

6.1 General

Additional investigations are only performed in buildings in which an initial investigation has already been performed following the procedure described in Clause 5. They can be performed throughout the year.

They shall assist in the technical diagnostic.

Additional investigations are used to identify:

— the sources of the radon;

— the radon entry routes in the building;

— the radon transfer pathways in the building.

The additional investigations require information such as:

— results of the initial investigation or previous ones and the conclusions of the associated reports;

— characteristics of the building itself and the site where it is built;

— occupant’s lifestyle;

— if necessary, the information collected during the technical diagnostic.

Additional investigations require the implementation of several measurement methods inside and, if necessary, outside the building.

6.2 Methodology for additional investigations

6.2.1 General

At first the site shall be visited. After the site tour has been completed, the additional investigations are launched following the steps below:

— building mapping;

— identification of the radon source(s) and the entry route(s);

— identification of the radon transfer pathways;

— drafting of the report of additional investigations.

Some of these steps may be carried out simultaneously.

6.2.2 Building mapping

The mapping provides a snapshot of the radon activity concentrations in the building at a given time.

The mapping of the building is based on the results of activity concentration measurements carried out throughout all building volumes (including cellars, box rooms, etc.) or in parts of the building, on the basis of the initial investigation results as well as the building characteristics.

Spot measurement methods (see ISO 11665-6) or continuous measurement methods (see ISO 11665-5) are recommended. Measurements are performed starting a few hours after the windows and doors are closed. Due to the great variability of the radon activity concentrations over time, these measurements shall be performed simultaneously or within a short time interval (over a few hours) in all volumes of the building.

The measurement results allow the identification of the volumes where radon activity concentrations are the highest. They are used to identify the part(s) of the building that will be prioritized for the operations aimed at pinpointing the radon sources, entry routes and transfer pathways.

6.2.3 Identification of radon sources and entry routes

6.2.3.1 General

Based on the information gathered in 6.1, several potential radon sources and entry routes can be tackled. They can be identified by deploying one or more of the measurement techniques set out below. Choice of measurement technique(s) and number of measurements scheduled depends on the situation encountered.

6.2.3.2 Radiometric measurement

Other radiometric measurements can be performed to supplement radon activity concentration, such as dose rate measurement. This latest measurement, expressed as equivalent dose rate ($\mu Sv \cdot h^{-1}$) or photon count [number of counts per second ($c \cdot s^{-1}$)], can quantify ambient gamma radiation and/or gamma radiation in contact with the soil and/or building materials.

These measurements are used to identify zones presenting the higher dose rates or photon counts characteristic of a significant presence of gamma-emitting radionuclides, especially radium-226 and its decay products.

NOTE In the event of significant divergence from background radiation, it might become necessary to take samples to perform a more precise measurement for a more fine-grained laboratory analysis so as to identify and quantify the radionuclides present.

6.2.3.3 Measurement in the air of the soil, in cracks and in piping runs

The method most frequently used to measure the radon activity concentration in the air of a soil, in apparent cracks or in piping runs, is spot measurement (see ISO 11665-6). Continuous measuring instruments may be used in certain circumstances (see ISO 11665-5).

Various techniques are used to collect air samples at the source of radon and before its exit and dilution in ambient air. A special sampling system is frequently required (syringe fitted with a filter, capillary tube, sampling probe) as the measuring point cannot normally be accessed directly.

6.2.3.4 Radon surface exhalation rate estimate

The surface exhalation rate allows the quantification of radon emitted from a given surface per unit of time. The surface under investigation may be: outdoor ground, the soil-building interface (beaten earth floor, floor slab, buried wall, etc.), building materials, etc. The measurement is performed complying with the requirements of ISO 11665-7.

6.2.3.5 Measurement in water

The water supplying the building under investigation or used for various in-building purposes may be measured for radon activity concentration using an appropriate measurement method (see ISO 13164).

6.2.3.6 Outdoor measurement

Outside air may sometimes prove a significant radon source. To measure the radon activity concentration outdoors, it is advisable to use a measuring device that operates continuously over several hours (at least four hours) (see ISO 11665-5).

6.2.4 Identification of transfer pathways

6.2.4.1 General

Several potential radon transfer pathways can be suspected. They can be identified by deploying one or more of the measurement techniques set out below. The choice of the measurement technique(s) and the number of measurements depends on the situation encountered.

6.2.4.2 Continuous measurement

Continuous radon measurement (see ISO 11665-5) provides an understanding of the time variations of the radon activity concentration in the volume under study in relation to changes in parameters such as occupancy patterns, heating, ventilation, etc. The implementation of continuous measurements in adjacent volumes enables the identification of radon transfer pathways between these volumes. These measurements are performed over a day-night cycle, generally covering at least one day and one night of occupancy.

NOTE 1 It is extremely useful to determine radon activity concentration during real routine occupation of a building volume. It can prove the determinant factor dictating the degree of urgency to implement remedial actions.

NOTE 2 It is extremely useful to determine the influence of a ventilation system on the radon activity concentration in a building volume. These measurements make it possible to test (cut-off, start-up, settings) the ventilation system. In practice, the simplest tests available are to test open doors and/or windows vs. closed doors and/or windows.

6.2.4.3 Spot measurement

Spot radon measurement (see ISO 11665-6) allows the pinpointing of transfer pathways between two volumes within the building. This measurement is performed at the interfaces between the two volumes (wall lining, floor), in piping runs, shafts, stairs, etc. Simultaneously to taking this measurement, the indoor radon activity concentration shall be measured in the volumes concerned.

6.2.4.4 Short-lived radon decay product measurement

The measurement of the potential alpha energy concentration of the short-lived radon decay products enables the equilibrium factor to be determined between the radon and its short-lived decay products (see ISO 11665-3). The value of the equilibrium factor is an indicator of the ventilation condition of the volume concerned.

6.3 Report of additional investigations

The report of additional investigations ensures traceability of the measurements and checks their conformity. The report of additional investigations shall contain the following information:

a) reference to this part of ISO 11665 and, if appropriate, to the national regulatory texts governing the situation;

b) context of the request for additional investigations;

c) date of the report of additional investigations;

d) sampling times: start and end time (date and hour);

e) sampling locations;

f) description of the methodology followed and justification of the measurements performed at the time of the additional investigations;

g) description of the measurement methods performed;

h) building mapping results and their interpretation;

i) results and interpretation of the measurements performed for identifying the sources and the entry routes;

j) results and interpretation of the measurement performed for identifying the transfer pathways;

k) conclusion with a summary of the interpretation of the measurement results and the identification of the radon sources, the entry routes and the transfer pathways.

Complementary information can be provided, such as the following:

— identification of the person requesting the additional investigations;

— references of the authors of the report;

— references of the persons who were in charge of the additional investigations;

— report reference code, written on every page of the report, with page numbering featuring the total number of pages; when a new version of the additional investigations report needs to be issued, it shall be given a new reference code or a new version index, and shall include a statement naming the original report it replaces;

— synthesis of the information collected in advance (information linked to the technical diagnostic, results of the initial investigation or previous ones, information linked to the building);

— a schematic drawing of the building, marking locations of the measuring points;

— description of the measurement conditions (sampling, environmental conditions).

7 Immediate post-mitigation testing of the technical solutions applied

Immediate post-mitigation testing of the technical solutions applied may be performed using short-term radon measurements. This phase is carried out in the building parts where the mitigation techniques were implemented as well as in the adjacent volumes, using a continuous measurement method of radon activity concentration (see ISO 11665-5).

Continuous radon measurement results can be used to assess the effectiveness of the implementation of any active mitigation technique (mechanical ventilation of the building or the basement, active sub-slab depressurization). The results of these continuous measurements are not representative of the average annual radon activity concentration.

NOTE These measurements can be performed at any time during and after the implementation of the mitigation solutions.

8 Control of the effectiveness of the technical solutions applied

The effectiveness shall be assessed following the procedure of the initial investigation phase with a new definition of the homogeneous zones. Measurements shall be performed under the conditions described in 5.4. This new initial investigation shall be carried out throughout the entire building rather than in the volumes and/or zones where the radon activity concentrations were highest.

NOTE 1 Any change to the building is liable to impact its radon transfer and thus trigger an increase in radon activity concentrations in a previously non-impacted part of the structure.

NOTE 2 When a mitigation technique is implemented, it can be necessary to monitor its correct operation over time.

9 Control of the sustainability

The sustainability of the building's behaviour towards radon shall be regularly assessed. The control of the sustainability is performed by measuring the radon activity concentration throughout the building following the initial investigation conditions described in Clause 5.

Annex A
(informative)

Organization of radon measuring phases in a building

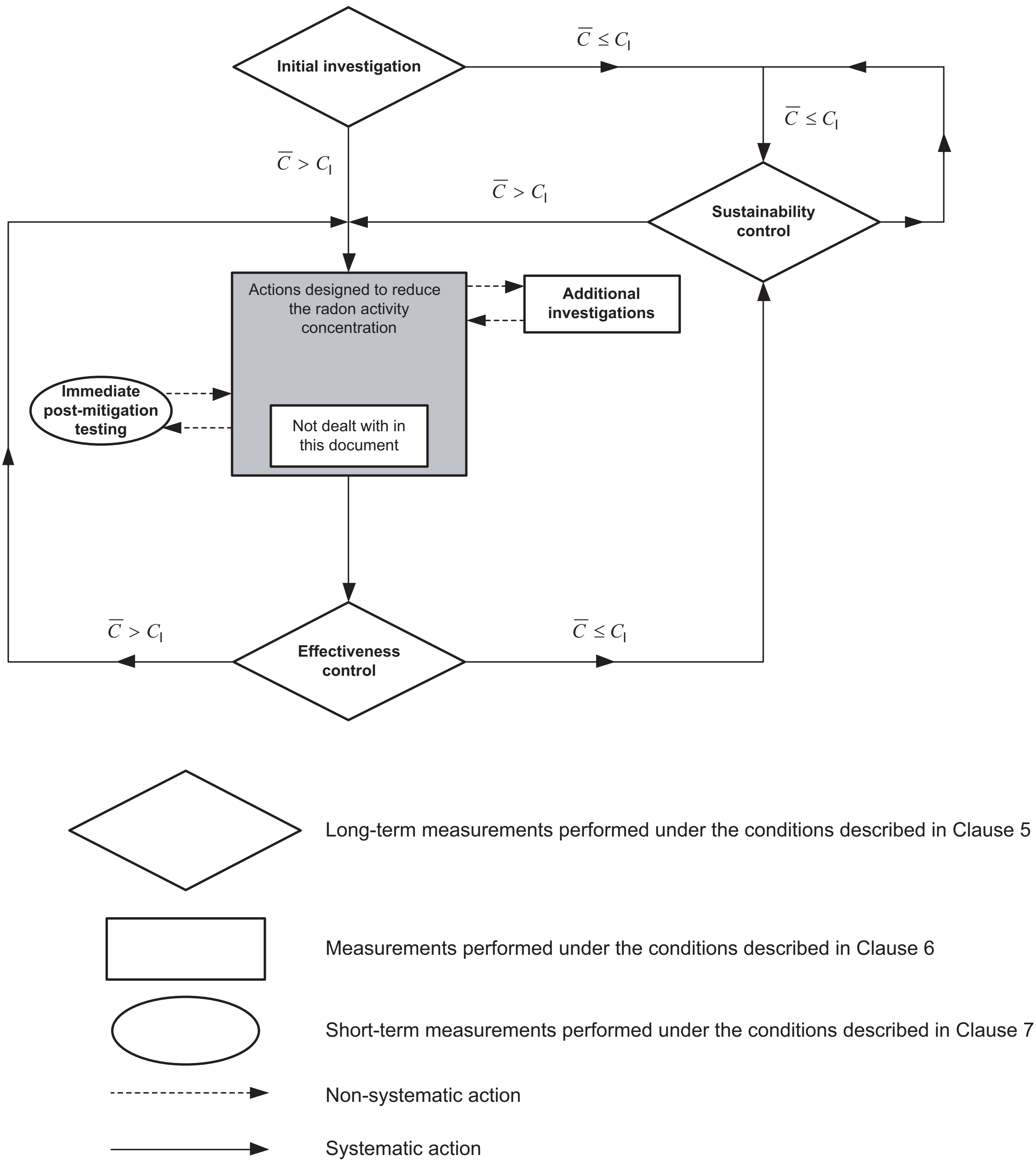

Figure A.1 — Organization of radon measuring phases in a building

Annex B
(informative)

Examples of underground buildings and buried levels

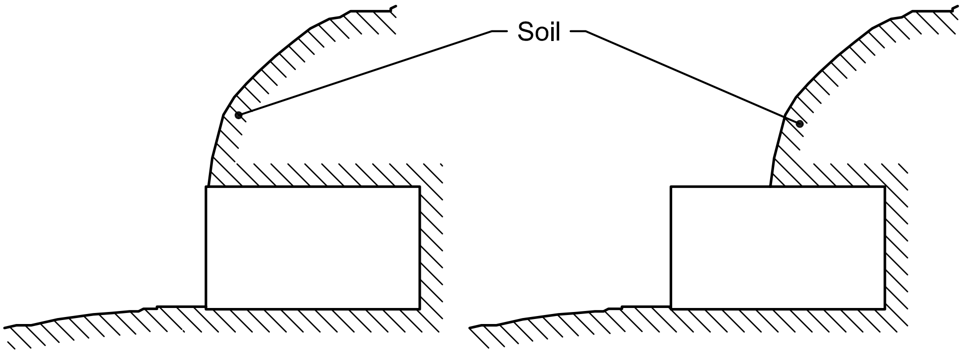

Figure B.1 — Schematic drawings of underground buildings

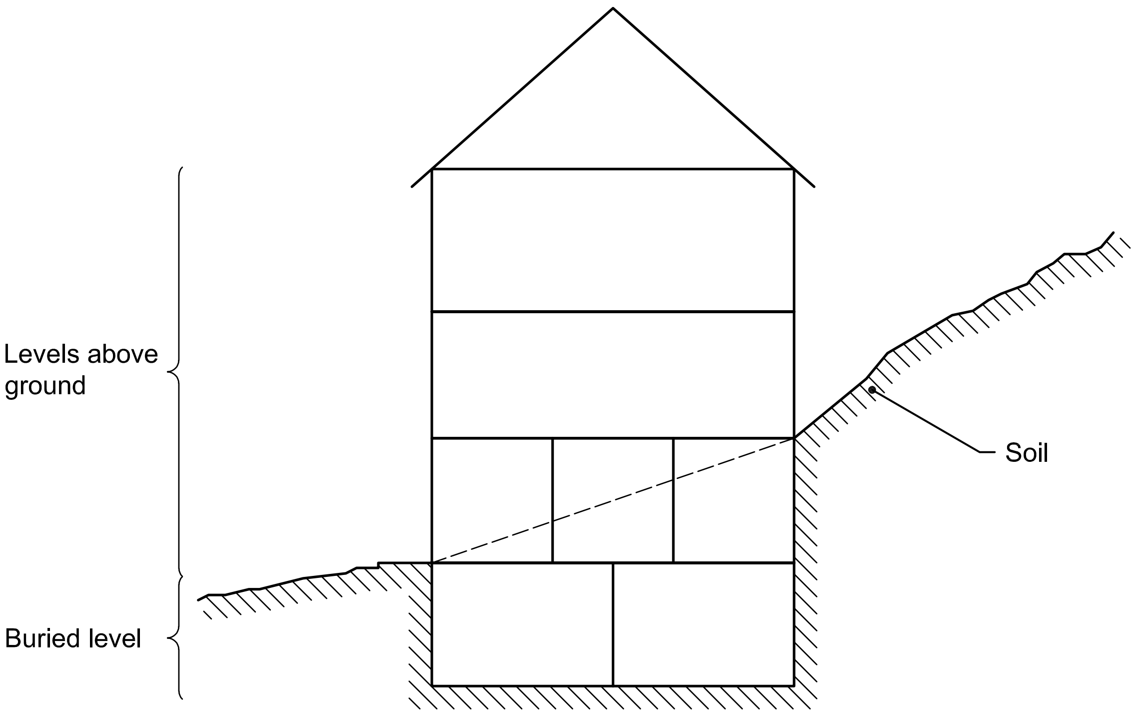

Figure B.2 — Schematic drawing of a building with one buried level

Annex C
(informative)

Initial investigation report

FOR EACH BUILDING

Owner identification	………
Requester identification	………

Intervening party identification:	Laboratory or company		…………………………………………
	Operator name		…………………………………………
	Operator skills		…………………………………………
Person in charge of the initial investigation	Name	Date	Signature

Building identification and location	Establishment name	…………………………………………
	Establishment type	Private house, school...
	Department	…………………………………………
	Municipality	…………………………………………
	Address	…………………………………………
	Place	…………………………………………
	Postal code	…………………………………………
Description of building	Number of levels	…………………………………………
	Ground area	…………………………………………
	Construction material	…………………………………………

Characterisation of zones	Define (on a drawing) the homogenous zones, their location and number	………………………………………… …………………………………………

FOR EACH HOMOGENOUS ZONE SELECTED

Characterisation of the homogenous zone	Approximate surface area	…………………………………………
	Number of rooms in the homogenous zone	…………………………………………
	Location	…………………………………………
	Number of measuring devices installed	…………………………………………
	Ventilation type	…………………………………………
	Occupation conditions	…………………………………………

Observations by the intervening party	……… ………

IN EACH HOMOGENOUS ZONE, FOR EACH MEASURING DEVICE INSTALLED

Identification of measuring device	Equipment type	………………………………………………………
	Serial number	………………………………………………………
	Other (specify)	………………………………………………………

Measuring device exposure conditions	Date	Start	day/month/year	time
		End	day/month/year	time
	Duration		………………………………………………………	
	Location inside the building		………………………………………………………	
	Sampling location	Level	………………………………………………………	
		Location of the room	………………………………………………………	
	Sampling height		…………………… (optimum height:1,50 m)	
	Distance from wall		…………………… (optimum distance: 0,20 m)	

LABORATORY TEST REPORT

Exposure duration	………	
Number of days room unoccupied during exposure	……… ……… ………	
Activity concentration	……………………………… Bq·m^{-3}	Expanded uncertainty (k = 2) ……………………………… Bq·m^{-3}

IN EACH HOMOGENOUS ZONE

Activity concentration of homogeneous zone	………………………………. Bq·m^{-3}

Comments	…… ……

Annex D
(informative)

Example of analysis of initial investigation measurement results

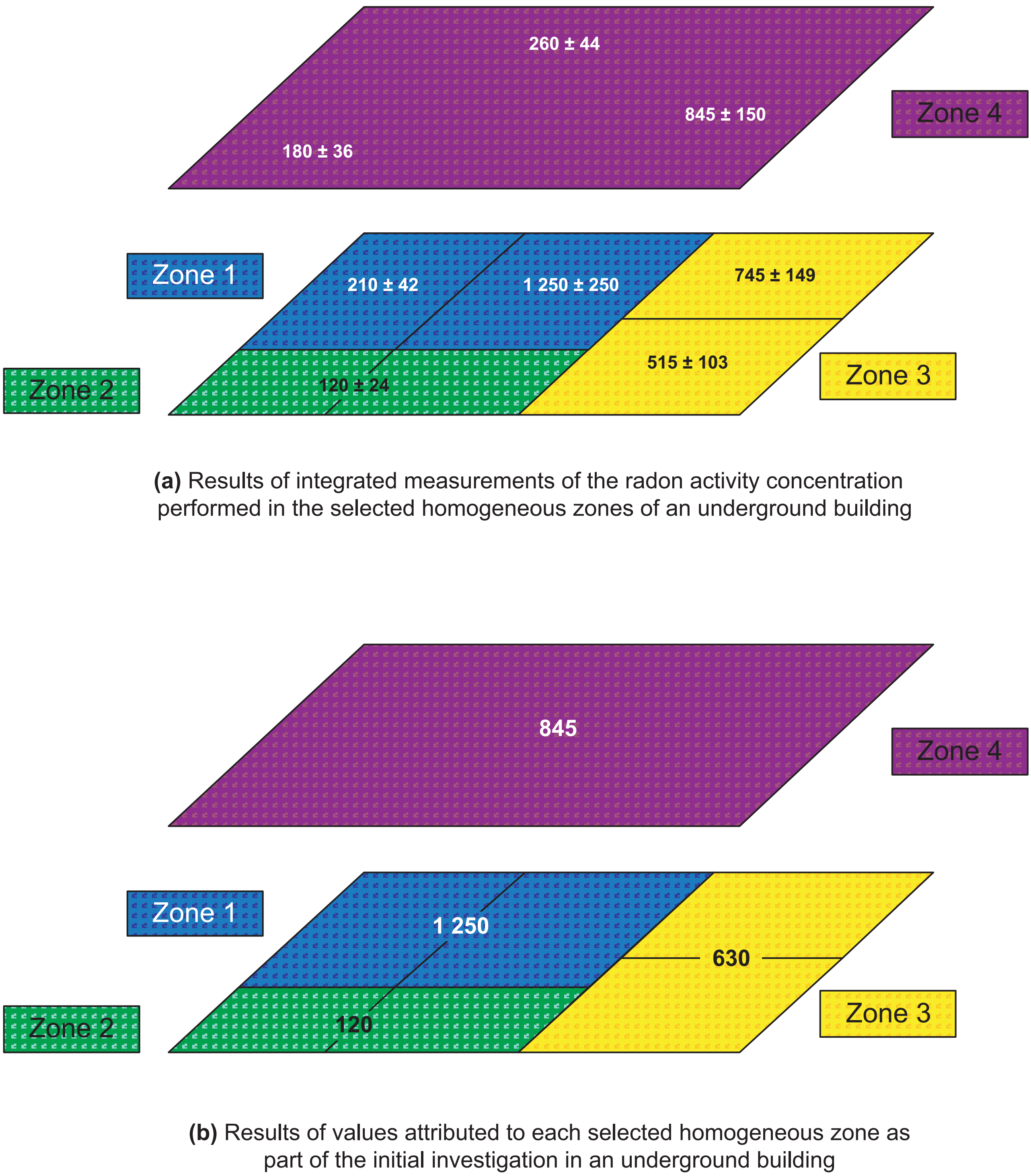

Figure D.1 — Example of the analysis (b) of radon measurement results (a) of an initial investigation performed in a building with two buried levels

Bibliography

[1] Nuclear Data Base issued from the Decay Data Evaluation Project. Available at: www.nucleide.org/DDEP_WG/DDEPdata.htm

[2] UNSCEAR. 2006 Report: *Effects of ionizing radiation* (Vol. 1, report to the General Assembly and two scientific annexes). United Nations Publication, New York, 2008

[3] Robé M.C.; Métivier H. *Le radon de l'environnement à l'homme, Collection Livre IPSN*. EDP Sciences, 1999

[4] Institute for Protection and Nuclear Safety — General Directorate for Health. National measurement campaign for domestic exposure to radon — Measurement report and mapping at 1 January 2000

[5] Collignan B. *Le radon dans les bâtiments existants: Guide pour la remédiation des constructions existantes et la prévention des constructions neuves*, guide technique CSTB, July 2008

[6] Building Research Establishment. *Guide to Radon Remedial Measures in Existing Dwellings: Dwellings with Cellars and Basements*. BRE, Watford, 1998

[7] United States Environmental Protection Agency. *Radon Reduction Techniques for Existing Detached Houses: Technical Guidance (Third Edition) for Active Soil Depressurization*. UPEPA Publication 625-R-93-011, Washington D.C., 1993

[8] World Health Organization. *WHO Handbook on indoor radon. A public health perspective*. WHO, Geneva, 2009

[9] Tokonami S. Why is 220Rn (Thoron) measurement important? *Radiat. Prot. Dosimetry*. 2010, 141 (4) pp. 335–339

[10] ISO 921, *Nuclear energy — Vocabulary*

[11] ISO 11665-2, *Measurement of radioactivity in the environment — Air: radon-222 — Part 2: Integrated measurement method for determining average potential alpha energy concentration of its short-lived decay products*

[12] ISO 11665-3, *Measurement of radioactivity in the environment — Air: radon-222 — Part 3: Spot measurement method of the potential alpha energy concentration of its short-lived decay products*

[13] ISO 11665-5, *Measurement of radioactivity in the environment — Air: radon-222 — Part 5: Continuous measurement method of the activity concentration*

[14] ISO 11665-6, *Measurement of radioactivity in the environment — Air: radon-222 — Part 6: Spot measurement method of the activity concentration*

[15] ISO 11665-7, *Measurement of radioactivity in the environment — Air: radon-222 — Part 7: Accumulation method for estimating surface exhalation rate*

[16] ISO 13164-1[1)], *Water quality — Measurement of the activity concentration of radon-222 — Part 1: General principles*

[17] ISO 13164-2[2)], *Water quality — Measurement of the activity concentration of radon-222 — Part 2: Gamma spectrometry method*

1) To be published.

2) To be published.

[18] ISO 13164-3[3], *Water quality — Measurement of the activity concentration of radon-222 — Part 3: Emanometric method*

[19] ISO 13164-4[4], *Water quality — Measurement of the activity concentration of radon-222 — Part 4: Test method using liquid scintillation counting*

[20] IEC 61577-1, *Radiation protection instrumentation — Radon and radon decay product measuring instruments — Part 1: General principles*

[21] IEC 61577-2, *Radiation protection instrumentation — Radon and radon decay product measuring instruments — Part 2: Specific requirements for radon measuring instruments*

[22] IEC 61577-3, *Radiation protection instrumentation — Radon and radon decay product measuring instruments — Part 3: Specific requirements for radon decay product measuring instruments*

3) To be published.

4) Under preparation.

ICS 13.040.01, 17.240

Price based on 20 pages