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

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

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

Partie 9: Méthode de détermination du flux d'exhalation des matériaux de construction

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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.

ISO 11665-9 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*

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

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

— *Part 11: Test method for soil gaz*

Measurement of radioactivity in the environment — Air:radon 222 — Part 9: Method for determining exhalation rate of building materials

1 Scope

This standard specifies a method for the determination of the free radon exhalation rate of a batch of stony building materials. The standard only refers to ^{222}Rn exhalation.

Any contribution made by thoron (^{220}Rn) in relation to the measurement result can be ignored when the described method is performed.

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 921, *Nuclear energy — Vocabulary*

ISO 11665-1[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 11929, *Determination of the characteristic limits (decision threshold, detection limit and limits of the confidence interval) for ionizing-radiation measurements — Fundamentals and application*

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 the following apply.

3.1.1
batch
amount of stony building materials that is regarded as a unit and for which it is assumed that it has uniform characteristics or an amount of fresh concrete produced under uniform conditions and which has the same strength and environmental class or which has the same composition

3.1.2
free volume
volume of the exhalation vessel reduced by the volume of the physical size of the stony building material test sample

1) Under elaboration.

3.1.3
radon standard
solution of ^{226}Ra or source of radon emanation with a defined activity or radon emanation rate respectively, which can be traced to the primary standard

3.1.4
sample
stony product drawn from a batch or an amount of fresh concrete taken from a batch

3.1.5
test portion
sample of the adsorber used to trap the radon exhaled from the laboratory sample

3.1.6
stony building material
product of stone or product that is made of one or more stony building materials and possibly admixtures and which has characteristics that meet previously set requirements after a formation process which may have been supplemented with a curing process if required

Note 1 to entry The curing process, in which a chemical reaction occurs, may take place under ambient conditions (cold binding products), under elevated temperature (baked products) or under elevated temperature and pressures (autoclaved products).

3.1.7
test sample
fraction of the sample that is prepared for the test

3.1.8
ventilation rate
rate at which the free volume is refreshed

Note 1 to entry The ventilation rate can be calculated by dividing the volume flow rate (in $m^3.s^{-1}$) by the free volume (in m^3).

3.2 Symbols

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

A_{Ra} ^{226}Ra activity of the radon standard, in Becquerel

ϕ_f Free radon exhalation rate, in Becquerel per second

R_n test portion n gross counting rate as the result of radon and/or radon decay products on the adsorber, in per second

R_0 blank counting rate, in per second

R_{min} Minimum detectable counting rate as the result of radon and/or radon decay products on the adsorber, in per second

V Free volume to which the radon exhales, in cubic metres

V_p Volume of the test sample, in cubic metres

F_{c_n} Calibration factor of the nth determination, in per Becquerel.second

t_0 blank counting time, in seconds

t_n counting time of the nth test portion, in seconds

t_w Elapsed time between the end of the adsorption period and the start of the count, in seconds

t_a Elapsed time between the start and the end of the adsorption period, in seconds

λ_{Rn} Radon decay constant, in per second

λ_v Ventilation rate, in per second

$u()$ Standard uncertainty associated with the measurement result

U Expanded uncertainty calculated by $U = k \cdot u()$ with $k = 2$

V_1 total uncertainty of the free radon exhalation rate, in Becquerel per second

V_2 dispersion of the results of the test samples, in Becquerel per second

$v(\phi)$ coefficient of variation of the free radon exhalation rate

$v(F_c)$ coefficient of variation of the calibration factor

$\overline{F_c}$ average calibration factor, in per Becquerel.second

$\overline{\phi_f}$ average free radon exhalation rate, in per Becquerel.second

k Coverage factor for which a value of 3 shall be used

4 Principle

The test sample of the stony building material is conditioned at (20 ± 2) °C and (50 ± 5) % relative humidity. After conditioning, the test sample is placed in an exhalation vessel so that radon exhalation takes place towards the free volume of the exhalation vessel.

The free radon exhalation rate is determined by flushing the radon activity concentration using nitrogen from the free volume during a defined period and by collecting it on an adsorber (purge and trap method).

The ventilation rate is chosen sufficiently larger than the radon decay rate to ensure that the radon exhalation rate approximates the free radon exhalation rate. The humidity of the gas, the volume flow rate and the temperature are kept at constant values whilst flushing. After the free volume has been flushed at least five times, the radon activity concentration in the free volume and in the outgoing nitrogen volume flow is constant. Next, the nitrogen volume flow is passed over an adsorber used to collect the radon. The activity of the adsorbed radon and/or radon decay products is determined using an integral measurement with a liquid scintillation counter after a defined collection period. The free radon exhalation rate is calculated starting from this.

The test method consists of consecutively:

- drawing samples in accordance with 5;
- preparing test samples in accordance with 5.2;
- performing the test in accordance with 6; and
- processing results in accordance with 8.

Determination methods that deviate from this method are described in Annexes A and B. The methods lead to a free radon exhalation rate which is equivalent to the free radon exhalation rate determined in accordance with the main text. Each of the methods described in Annex A or B may, therefore, be applied instead of the main text.

5 Sampling

5.1 General

Randomly take at least three representative samples of a batch of stony building materials except when a stony material made of cement concrete is involved.

If the batch consists of products made of cement concrete, take at least three representative samples of the fresh concrete paste during pouring of the building product.

Prepare a test cube from each of the fresh cement concrete samples, which measures 150 mm × 150 mm × 150 mm with a tolerance of no more than 0,5 %, and allow it to cure for 28 days.

In the case of concrete products, at least three samples may be drawn at random from a batch of concrete products.

NOTE The smaller the numbers of samples, the greater the statistical uncertainty is in the result of the measurement; see 8.2.

5.2 Test samples

5.2.1 Apparatus and devices

a) Conditioning room

Room in which the temperature can be set to a value of (20 ± 2) °C and the relative humidity can be set to a value of (50 ± 5) %.

b) Calibrated length measuring instrument

— reading uncertainty: at most 1 mm.

c) Calibrated weighing apparatus

— measuring range: at least 1,5 times the mass of the test sample;

— reading uncertainty: at most 0,01 %.

d) Relative-humidity meter

— measuring range: 40 % to 60 %;

— measurement uncertainty: at most 3 %;

— reading uncertainty: at most 1 %.

e) Temperature gauge

— measuring range: 15 °C to 25 °C;

— measurement uncertainty: at most 1 °C;

— reading uncertainty: at most 0,5 °C.

f) Saw

5.2.2 Number and dimensions

Take or prepare one test sample from each sample. A test sample can be sawed from a sample that is too large for the exhalation vessel (blocks, panels, units).

Ensure, however, that the volume of the exhalation vessel is at least twice as large as the volume of the test sample or of the combined volume of test samples that are to be tested simultaneously. Determine, for each test sample, the mass with an accuracy of three decimal places in kg, the dimension with an accuracy of three decimal places in m, and, if required, the external surface with an accuracy of three decimal places in square metres if that surface cannot easily be derived from the dimensions.

NOTE The total volume of the test samples is not prescribed in this standard. It should be obvious that as the volume becomes greater, the material shows a higher exhalation rate and, when the adsorption time remains unchanged, the uncertainty of the exhalation rate decreases. In general, test samples with a volume in the range of 3 dm^3 to 10 dm^3 are aimed at.

5.2.3 Conditioning

5.2.3.1 Cement concrete

Store the test samples prepared from cement concrete in the conditioning room after the curing period of 28 days has elapsed. Set the temperature and the relative humidity of the conditioning room at (20 ± 2) °C and (50 ± 5) %. Wait until the moisture content is in equilibrium with the set conditions. This is the case if the mass of the sample over a period of seven days deviates by less than 0,07 % from the value determined during the previous measurement. Once this is the case, testing can start. Conditioning, however, shall not last longer than eight weeks. If the moisture content is not in equilibrium by this time, testing shall start between eight and twelve weeks after the curing period of 28 days.

NOTE The age of the test sample may influence the radon exhalation. As a result of the aging processes, the free radon exhalation rate of building materials can change during the utilization period. It is, for example, known that the free radon exhalation rate of certain types of cement concrete may decrease over a period of 6 years by approximately 50 % when stored at a relative humidity of approximately 50 %.

5.2.3.2 Other stony materials

Store the test samples, after preparation, in the conditioning room. Set the temperature and the relative humidity of the conditioning room at (20 ± 2) °C and (50 ± 5) %. Wait until the moisture content is in equilibrium with the set conditions. This is the case if the mass of the sample over a period of seven days deviates by less than 0,07 % from the previous measurement. Once this is the case, testing can start. If the moisture content is not in equilibrium, the test shall start twelve weeks after conditioning has begun.

6 Test

6.1 Principle

The test shall be performed using a method as described in 6.3 using apparatus and devices as determined in 6.2. The results of the test shall be processed as set down in 7.

6.2 Apparatus, devices and admixtures

6.2.1 Apparatus and devices

a) Adsorption column

Glass U tube of sufficient length and diameter. The tube shall be able to contain approximately 5 g silica gel.

b) Dewar flask

c) Drying column

Glass U tube of sufficient length and diameter. The tube shall be able to contain 20 g of KOH pellets.

d) Exhalation vessel

A vessel in which one or more test samples can be placed without touching each other or the walls of the vessel and which can be sealed airtight. The dimensions of the vessel shall be so that adequate flushing of the free volume is possible. Ensure that the volume of the exhalation vessel has at least twice the volume of the test sample. The material used to manufacture the exhalation vessel shall not release radon.

The vessel shall have an inlet and an outlet to allow flushing of the free volume with nitrogen, and shall be provided with a thermometer and a relative-humidity meter. The ingoing volume flow shall be distributed over various inlet points to ensure that the whole inner space of the vessel is flushed uniformly. Ensure that there are no dead corners in this inner space. Volume flow rate meters shall be mounted in the lines used to supply and exhaust the nitrogen.

e) Gas washing bottles

— number: at least one;

— volume: 150 ml to 200 ml.

f) Calibrated length measuring instrument

— reading uncertainty: at most 1 mm.

g) Sample holders for the liquid scintillation counter

Glass vials with a volume of approximately 20 ml.

h) Relative-humidity meter

— measuring range: 40 % to 60 %;

— measurement uncertainty: at most 3 % in absolute terms;

— reading uncertainty: at most 1 %.

i) Round bottom flasks or gas washing bottles

Sufficient volume to ensure the ^{226}Ra solution can be flushed.