DRAFT INTERNATIONAL STANDARD ISO/DIS 11665-10

ISO/TC **85**/SC **2** Secretariat: **AFNOR**

Voting begins on **2013-03-28** Voting terminates on **2013-06-28**

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

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

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

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

Partie 10: Détermination du coefficient de diffusion du radon des matériaux imperméables par mesurage de l'activité volumique du radon

ICS 13.040.01; 17.240

To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.

Pour accélérer la distribution, le présent document est distribué tel qu'il est parvenu du secrétariat du comité. Le travail de rédaction et de composition de texte sera effectué au Secrétariat central de l'ISO au stade de publication.

THIS DOCUMENT IS A DRAFT CIRCULATED FOR COMMENT AND APPROVAL. IT IS THEREFORE SUBJECT TO CHANGE AND MAY NOT BE REFERRED TO AS AN INTERNATIONAL STANDARD UNTIL PUBLISHED AS SUCH.

IN ADDITION TO THEIR EVALUATION AS BEING ACCEPTABLE FOR INDUSTRIAL, TECHNOLOGICAL, COMMERCIAL AND USER PURPOSES, DRAFT INTERNATIONAL STANDARDS MAY ON OCCASION HAVE TO BE CONSIDERED IN THE LIGHT OF THEIR POTENTIAL TO BECOME STANDARDS TO WHICH REFERENCE MAY BE MADE IN NATIONAL REGULATIONS.

RECIPIENTS OF THIS DRAFT ARE INVITED TO SUBMIT, WITH THEIR COMMENTS, NOTIFICATION OF ANY RELEVANT PATENT RIGHTS OF WHICH THEY ARE AWARE AND TO PROVIDE SUPPORTING DOCUMENTATION.

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.

ISO 11665-10 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: Origin 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 dense building materials*

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

— *Part 11: Method for soil gas*

Measurement of radioactivity in the environment — Air: radon 222 — Part 10: Determination of the diffusion coefficient in waterproof materials using activity concentration measurement

1 Scope

This standard specifies assumptions and boundary conditions that shall be met by methods intended for determining the radon diffusion coefficient in waterproofing materials such as bitumen or polymeric membranes, coatings or paints.

This standard is not applicable for porous materials, where radon diffusion depends on porosity and moisture content.

2 Normative references

Les documents ci-après, dans leur intégralité ou non, sont des références normatives indispensables à l’application du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

ISO 921, *Nuclear energy — Vocabulary*

ISO 80000-10*, Quantities and units – Part 10: Atomic and nuclear physics*

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 11665-5, *Measurement of radioactivity in the environment — Air: Radon-222 — Part 5: Continuous measuring method of the activity concentration*

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

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

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

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, ISO 921 and ISO 80000-10 and the following apply.

3.1.1
diffusion length *l*
distance crossed by an atom due to diffusion forces before decaying

Note1 to entry Diffusion length, l, is expressed by the relationship given in Formula (1)

$$l = (D/\lambda)^{1/2} \tag{1}$$

where

D is the diffusion coefficient, in square metres per second;

λ is the decay constant per second.

3.1.2
diffusive radon exhalation rate *E*
value of the activity concentration of radon atoms that leave a material per unit time

Note 1 to entry For the purpose of this standard only the diffusion transport through the sample is taken into account. The diffusive radon exhalation rate is given by Formula (2) (Fick's law)

$$E = -D\frac{\partial C}{\partial x} \tag{2}$$

where

D is the diffusion coefficient, in square metres per second;

C is the activity concentration of 222Rn, in becquerels per cubic metre;

x is the distance in matter.

3.1.3
non-stationary radon diffusion
time dependent radon diffusion through the sample when the radon concentration within the sample is changing (in dependence on time, distance from the surface exposed to radon and the radon concentration in the source container) and the radon exhalation rate from the sample into the receiver container is also changing; this occurs during the time when radon concentration in the source container is not steady and in the time interval that immediately follows the moment when the steady concentration in the source container is established; one-dimensional non-stationary radon diffusion is described by the partial differential equation:

$$D \cdot \frac{\partial^2 C}{\partial x^2} - \lambda \cdot C = \frac{\partial C}{\partial t} \tag{3}$$

where

D is the diffusion coefficient, in square metres per second;

C is the activity concentration of 222Rn, in becquerels per cubic metre;

x is the distance in matter in metres;

λ is the decay constant per second.

3.1.4
stationary radon diffusion
time independent radon diffusion through the sample; stationary radon diffusion is characterized by a stable (time independent) radon distribution within the sample and consequently by a stable radon exhalation rate from the sample into the receiver container; one-dimensional stationary radon diffusion is described by the differential equation:

$$D \cdot \frac{\partial^2 C}{\partial x^2} - \lambda.C = 0 \qquad (4)$$

where

- D is the diffusion coefficient, in square metres per second;
- C is the activity concentration of 222Rn, in becquerels per cubic metre;
- x is the distance in matter in metres;
- λ is the decay constant per second.

3.1.5
decisive measurement of radon concentrations
the measurement of the time courses of radon concentrations in the source and receiver containers that is used for calculating the radon diffusion coefficient; the duration of the decisive measurement can be shorter or the same as the duration of the test

3.1.6
minimum duration of the decisive measurement for non-stationary radon diffusion
such period of time in the frame of the decisive measurement of radon concentrations in the source and receiver containers taken during the phase of non-stationary diffusion ensuring the uncertainty of the radon diffusion coefficient assessment lower than ± 20 %

3.1.7
minimum duration of the decisive measurement for stationary radon diffusion
such period of time in the frame of the decisive measurement of radon concentrations in the source and receiver containers taken during the phase of stationary diffusion ensuring the uncertainty of the radon diffusion coefficient assessment lower than ± 20 %

3.1.8
minimum radon concentration in the source container
such concentration of radon in the source container which for the particular sample characterised by the d/l ratio ensures values of radon concentration in the receiver container measurable with uncertainty lower than 10 %

3.2 Symbols

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

- λ Radon decay constant, in per second
- λ_V Air exchange rate characterising the ventilation of the receiver container, in per second
- C Activity concentration, in becquerel per cubic metre
- C_a Activity concentration in a particular container of the measuring device, in becquerels per cubic metre

C_s Activity concentration on the surface of the sample, in becquerels per cubic metre

C_{rc} Activity concentration in the receiver container, in becquerels per cubic metre

C_{sc} Activity concentration in the source container, in becquerels per cubic metre

D Radon diffusion coefficient, in square metre per second

d Thickness of the sample, in metre

E Diffusive radon exhalation rate, in becquerels per square metre per second

E_{rc} Diffusive radon exhalation rate from the sample to the receiver container, in becquerels per square metre per second

h Radon transfer coefficient, in metre per second

i Index

l Diffusion length, in metre

S_s Area of the sample, in square metres

t Time, in seconds

Δt Duration of the considered time step between time t_{i-1} and t_i, in seconds

V Volume of the receiver container, in cubic metres

x Distance from the surface of the sample exposed to radon, in metre

4 Principle of the test method

The sample of the tested material is placed between the air-tight source and the receiver containers, and the joint is carefully sealed.

Radon activity concentration in both containers can be measured using continuous or spot measurement methods as described in ISO 11665-5 and 11665-6.

By means of the certified artificial radon source, the radon concentration in the source container is kept on a high level (usually within the range 1 MBq m^{-3} to 100 MBq m^{-3}). The radon that diffuses through the sample is monitored using calibrated radon monitor in the receiver container.

Using an appropriate mathematical process (either analytical or numerical), the radon diffusion coefficient is afterwards calculated from the time-dependent courses of the radon activity concentrations measured in the source and receiver containers, and the area and thickness of the tested sample.

5 Measuring system

5.1 Components of the measuring system

The measuring system for determining the radon diffusion coefficient in the radon barrier materials shall comprise the following components:

a) at least two air-tight containers (source and receiver), each with a minimum air volume of 0,5 dm^3 and made from metal materials (for example aluminium, rustless steel, etc.) of a thickness that effectively eliminates radon transport between the air inside and outside the containers; each container shall be equipped with a test area of at least 0,5 dm^2 surrounded by flanges for fixing the tested material; the minimum width of the flanges shall be 10 mm and their arrangement shall eliminate the transport of radon from the source container to the receiver container; each container shall be further equipped with an appropriate number of valves intended for ventilating the containers, for measuring the pressure differences between the containers, for extracting air samples for control measurements of radon concentration and for connecting to an artificial radon source;

b) a measuring instrument capable of determining the thickness of the tested sample with accuracy ± 0,01 mm (maximum standard relative uncertainty of measurement 5 %);

c) a certified artificial source of radon capable of creating a radon concentration in the source container within the range 1 MBq m^{-3} to 100 MBq m^{-3};

d) an air-tight flow pump with the range of air flow rates 0,1 dm^3/min to 0,5 dm^3/min that is used in some measurement methods in a closed circuit with an artificial radon source and a source container;

e) a calibrated measuring device for monitoring the radon activity concentration in the receiver container with standard relative uncertainty 10 % and a dynamic measuring range from 500 Bq m^{-3} to 1,0 MBq m^{-3};

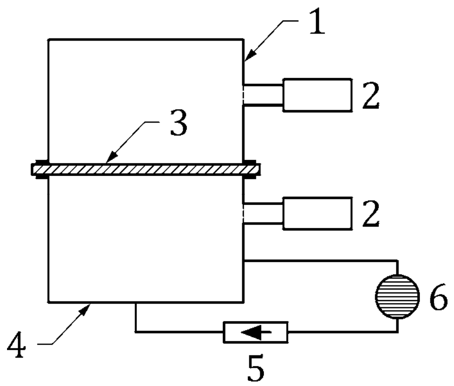
f) a calibrated measuring device for monitoring the radon activity concentration in the source container with standard relative uncertainty 10 % and a dynamic measuring range from 10 kBq m^{-3} to 100,0 MBq m^{-3};

g) a measuring instrument for determining the relative pressure difference between the air volume in the source container and the air volume in the receiver container with standard relative uncertainty 10 % and a dynamic measuring range from 1 Pa to 150 Pa;

h) suitable sensors and a data storage system capable of continuously monitoring the temperature and relative humidity of air, atmospheric pressure and radon activity concentration in the place where the measuring device is positioned.

5.2 Configuration of the measuring system

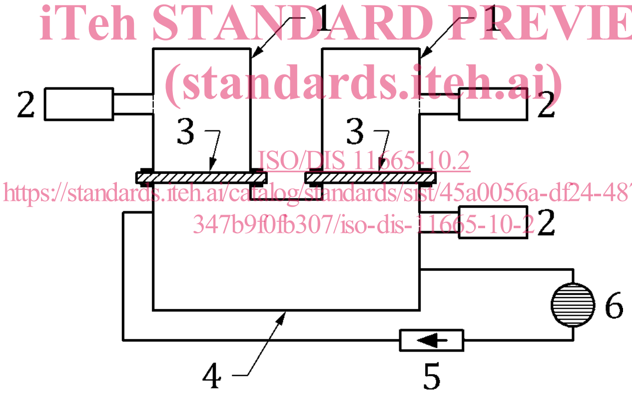
In the simplest case, the measuring system can comprise one source container, one receiver container and a radon source connected to the source container (Figure 1). If more than one sample is to be measured under equal conditions, it is convenient to use a measuring system comprising more than one receiver container assembled on one source container (Figure 2), or a set of pair containers (source + receiver) connected to the radon source in a parallel circuit (Figure 3) or connected to each other and to the radon source through the source containers in a serial circuit.



Key

1 receiver container
2 radon detector
3 tested sample
4 source container
5 pump
6 radon source

Figure 1 — Measuring system comprising one source container and one receiver container



Key

1 receiver container
2 radon detector
3 tested sample
4 source container
5 pump
6 radon source

Figure 2 — Measuring system comprising two receiver containers assembled on one source container