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Merjenje radioaktivnosti v okolju - Zrak: radon Rn-222 - 3. del: Točkovna metoda za merjenje potencialne koncentracije alfa energije njegovih kratkoživih razpadnih produktov (ISO/FDIS 11665-3:2019)

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 (ISO/FDIS 11665-3:2019)

Ermittlung der Radioaktivität in der Umwelt - Luft: Radon-222 - Teil 3: Punktmessverfahren der potenziellen Alpha-Energiekonzentration der kurzlebigen Radon-Folgeprodukte (ISO/FDIS 11665-3:2019)

Mesurage de la radioactivité dans l'environnement - Air: radon 222 - Partie 3: Méthode de mesure ponctuelle de l'énergie alpha potentielle volumique de ses descendants à vie courte (ISO/FDIS 11665-3:2019)

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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

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

Partie 3: Méthode de mesure ponctuelle de l'énergie alpha potentielle volumique de ses descendants à vie courte

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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

This second edition cancels and replaces the first edition (ISO 11665-3:2012), of which it constitutes a minor revision. The changes compared to the previous edition are as follows:

— update of the Introduction;

— update of the Bibliography.

A list of all the parts in the ISO 11665 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Radon isotopes 222, 219 and 220 are radioactive gases produced by the disintegration of radium isotopes 226, 223 and 224, which are decay products of uranium-238, uranium-235 and thorium-232 respectively, and are all found in the earth's crust (see ISO 11665-1:2019, Annex A for further information). Solid elements, also radioactive, followed by stable lead are produced by radon disintegration[1].

When disintegrating, radon emits alpha particles and generates solid decay products, which are also radioactive (polonium, bismuth, lead, etc.). The potential effects on human health of radon lie in its solid decay products rather than the gas itself. Whether or not they are attached to atmospheric aerosols, radon decay products can be inhaled and deposited in the bronchopulmonary tree to varying depths according to their size[2][3][4][5].

Radon is today considered to be the main source of human exposure to natural radiation. UNSCEAR[6] 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 (see ISO 11665-1:2019, Annex A). For this reason, references to radon in this document refer only to radon-222.

Radon activity concentration can vary from one to more 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 and building materials, weather conditions, and on the degree of containment in the areas where individuals are exposed.

As radon tends to concentrate in enclosed spaces like houses, the main part of the population exposure is due to indoor radon. Soil gas is recognized as the most important source of residential radon through infiltration pathways. Other sources are described in other parts of ISO 11665 and ISO 13164 series for water[7].

Radon enters into buildings via diffusion mechanism caused by the all-time existing difference between radon activity concentrations in the underlying soil and inside the building, and via convection mechanism inconstantly generated by a difference in pressure between the air in the building and the air contained in the underlying soil. Indoor radon activity concentration depends on radon activity concentration in the underlying soil, the building structure, the equipment (chimney, ventilation systems, among others), the environmental parameters of the building (temperature, pressure, etc.) and the occupants' lifestyle.

To limit the risk to individuals, a national reference level of 100 Bq.m^{-3} is recommended by the World Health Organization[5]. Wherever this is not possible, this reference level should not exceed 300 Bq·m^{-3}. This recommendation was endorsed by the European Community Member States that should establish national reference levels for indoor radon activity concentrations. The reference levels for the annual average activity concentration in air should not be higher than 300 Bq·m^{-3}[5].

To reduce the risk to the overall population, building codes should be implemented that require radon prevention measures in buildings under construction and radon mitigating measures in existing buildings. Radon measurements are needed because building codes alone cannot guarantee that radon concentrations are below the reference level.

Variations of a few nanojoules per cubic metre to several thousand nanojoules per cubic metre are observed in the potential alpha energy concentration of short-lived radon decay products.

The potential alpha energy concentration of short-lived radon-222 decay products in the atmosphere can be measured by spot and integrated measurement methods (see ISO 11665-1). This document deals with spot measurement methods. A spot measurement of the potential alpha energy concentration relates to the time when the measurement is taken and has no significance in annual exposure. This type of measurement does not therefore apply when assessing the annual exposure.

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

1 Scope

This document describes spot measurement methods for determining the activity concentration of short-lived radon-222 decay products in the air and for calculating the potential alpha energy concentration.

This document gives indications for performing a spot measurement of the potential alpha energy concentration, after sampling at a given place for several minutes, and the conditions of use for the measuring devices.

The measurement method described is applicable for a rapid assessment of the potential alpha energy concentration. The result obtained cannot be extrapolated to an annual estimate potential alpha energy concentration of short-lived radon-222 decay products. Thus, this type of measurement is not applicable for the assessment of annual exposure or for determining whether or not to mitigate citizen exposures to radon or radon decay products.

This measurement method is applicable to air samples with potential alpha energy concentration greater than 5 nJ/m^3.

NOTE This document does not address the potential contribution of radon-220 decay products.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 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/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

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

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

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 apply.

3.2 Symbols

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

C_i	activity concentration of the nuclide i, in becquerels per cubic metre
$E_{\mathrm{AE},i}$	alpha particle energy produced by the disintegration of the nuclide i, in joules
$E_{\mathrm{AEt},i}$	total alpha particle energy potentially produced by the nuclide i, in joules
$E_{\mathrm{PAE},i}$	potential alpha energy of the nuclide i, in joules
$E_{\mathrm{PAEC},i}$	potential alpha energy concentration of the nuclide i, in joules per cubic metre
$E^{*}_{\mathrm{PAEC},i}$	decision threshold of the potential alpha energy concentration of the nuclide i, in joules per cubic metre
$E^{\#}_{\mathrm{PAEC},i}$	detection limit of the of the potential alpha energy concentration of the nuclide i, in joules per cubic metre
$E^{\triangleleft}_{\mathrm{PAEC},i}$	lower limit of the confidence interval of the potential alpha energy concentration of the nuclide i, in joules per cubic metre
$E^{\triangleright}_{\mathrm{PAEC},i}$	upper limit of the confidence interval of the potential alpha energy concentration of the nuclide i, in joules per cubic metre
I_j	j^{th} number of gross counts obtained between times t_j and t_{cj}
$I_{0,j}$	j^{th} number of background counts obtained between times t_j and t_{cj}
$k_{i,j}$	coefficient related to the j^{th} number of gross count for radon decay product i, depending on the decay constants of the radon decay products, the sampling duration, t_s, and the times t_j and t_{cj}, per square second
N_i	number of atoms of the nuclide i
n	counting number depending on the gross alpha counting protocol used
Q	sampling flowrate, in cubic metres per second
t_{cj}	end time of counting j, in seconds
t_j	start time of counting j, in seconds
t_s	sampling duration, in seconds
U	expanded uncertainty calculated by $U = k \cdot u(\,)$ with $k = 2$
$u(\,)$	standard uncertainty associated with the measurement result
$u_{\mathrm{rel}}(\,)$	relative standard uncertainty
V	sampled volume, in cubic metres
ε_c	counting efficiency, in pulses per disintegration
λ_i	decay constant of the nuclide i, per second

4 Principle of the measurement method

Spot measurement of the potential alpha energy concentration of short-lived radon-222 decay products is based on the following elements:

a) grab sampling, at time t, of short-lived radon decay products contained in a volume of air representative of the atmosphere under investigation, using a high-efficiency filtering membrane;

b) repeated gross alpha measurements of the collected decay products using a detector sensitive to alpha particles; the counting stage starts after sampling has stopped;

c) calculation of the activity concentrations of the radon decay products using the laws of radioactive decay and the counting results from a preset duration, repeated at given times.

The gross alpha measurement method quantifies alpha particles emitted by short-lived radon decay products. The ^{222}Rn decay product chain shows that 99,98 % of the decays of ^{218}Po result in the emission of alpha particles. It can, therefore, be considered as a pure alpha emitter. ^{214}Pb and ^{214}Bi are not alpha emitters, but they contribute to the appearance of alpha particles from the decay of ^{214}Po.

After collecting the air sample, the gross alpha activity is measured for various counting durations. Because of the fast decay of radon decay products, the isotopic composition of a sample rapidly changes during collection as well as during the counting durations. Repeated measurements of the gross alpha activity are necessary in order to describe the decay of the sample and thereby calculate the amounts of the various decay products which were originally collected in the air sample.

NOTE Although ^{222}Rn and its decay products are usually found in higher quantity, environmental air samples can also contain significant activity of radionuclides of the ^{220}Rn decay chain as well as other airborne long-lived radionuclides. In such cases, the formulas and procedures given in this document need to be adapted to take into account these additional radionuclides.

5 Equipment

The apparatus shall include a sampling system and a detection system composed of a detector connected to a counting system (see Figure 1). The measuring devices used shall be in accordance with IEC 61577-1 and IEC 61577-3.

The sampling system shall include the following components:

a) an open filter holder allowing fast and easy removal of the filter after sampling;

b) a pump;

c) a high-efficiency particulate air filter (HEPA filter with a minimum efficiency of 99,97 % for a particle size of 0,3 µm);

d) a flowmeter and a chronometer;

Possible detectors include the following:

— a photomultiplier associated with a sensitive scintillation surface [for example ZnS(Ag)];

— a silicon semi-conductor that is sensitive to alpha particles.

The detector, connected to a pulse counting system, shall have a sensitive detection surface at least equal in diameter to the filtering membrane.