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

Part 11:
Test method for soil gas with sampling at depth

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

Partie 11: Méthode d'essai pour le gaz du sol avec un prélèvement en profondeur

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Foreword

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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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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

The committee responsible for this document is 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: Test methods for exhalation rate of building materials*

— *Part 11: Test method for soil gas with sampling at depth*

The following part is under preparation:

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

Introduction

Radon isotopes 222, 220 and 219 are radioactive gases produced by the disintegration of radium isotopes 226, 224 and 223, which are decay products of uranium-238, thorium-232 and uranium-235, respectively, and are all found in the Earth's crust. 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.

Radon is today considered to be the main source of human exposure to natural radiation. Reference [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. For this reason, references to radon in this part of ISO 11665 refer only to radon-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 firstly on the amount of radon emitted by the soil and the building materials in each area and, secondly, on the degree of containment and weather conditions 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 (building materials) and ISO 13164 (water).

Measurements of radon in the soil gas are performed for several applications dealing with radon risk management (drawing up of radon potential maps, defining radon-prone areas, characterization of radon potential of building sites, characterization of soil contaminated with radium-226, defining mitigation techniques to be applied in a building, verification of applied mitigation techniques, etc.), and phenomenological observation (understanding radon transport mechanisms in the soil and from the soil into the building, identification and analysis of radon entry parameters, gas activity measurement for survey of CO_2, volcanic eruption prediction, earthquake prediction, etc.).

The radon activity concentrations in the soil gas not only vary substantially at the season scale but also from day to day and even from hour to hour. It also varies in space in the horizontal, as well as the vertical dimension, depending on the following parameters characterizing the soil properties[3][4][5][19]:

— geochemical parameters of soils (mainly distribution of uranium and radium in soils and rocks and their localization influencing the radon emanation);

— physical parameters of all present layers of soils (grain size, permeability, porosity and effective porosity, soil moisture and water saturation, density);

— geological situation (thickness of Quaternary cover, weathering character of the bedrock, stratification, modification of layers by various antropogeneous activities);

— soil structure (deformation, presence of cracks);

— hydrological and geodynamic processes (transport of gaseous and liquid substances in porous and fractured environment, radium and radon in underground/fissure water);

— geomorphological situation (location of the area in a valley, on the slopes, or on the top of a hill);

— exogenous/meteorological factors (temperature, pressure, precipitation).

Because of these fluctuations, standardized measurement protocols are needed in order to ensure accurate and consistent measurement results of radon in the soils to ensure that they can be compared in time and space.

Depending on the depth, the values usually found in the soil gas are normally between a few hundred becquerels per cubic metre and several hundred of thousand becquerels per cubic metre. Activity concentrations can reach several billions of becquerels per cubic metre in radium-rich soils.

Theoretically, the radon activity concentration in the soil gas can be defined for any variable depth below the ground surface and it generally increases with depth below the surface in an ideal homogeneous soil[6]. But there is a minimal depth below the ground surface, at which the parameter can be really measured. The minimal depth depends on the soil properties at a given place and on the measurement method used. In particular, it depends on the volume of the soil gas sample. When the depth below the ground surface is lower than the above mentioned minimal depth, the soil gas sample is diluted with atmospheric air and the real value of radon activity concentration in the soil gas is underestimated (see Annex A).

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

