

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Radiation protection instrumentation – Radon and radon decay product measuring instruments –

Part 4: Equipment for the production of reference atmospheres containing radon isotopes and their decay products (STAR)

Instrumentation pour la radioprotection – Instruments de mesure du radon et des descendants du radon –

Partie 4: Dispositif pour la réalisation d'atmosphères de référence contenant des isotopes du radon et leurs descendants (STAR)



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

RADIATION PROTECTION INSTRUMENTATION – RADON AND RADON DECAY PRODUCT MEASURING INSTRUMENTS –

Part 4: Equipment for the production of reference atmospheres containing radon isotopes and their decay products (STAR)

FOREWORD

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International Standard IEC 61577-4 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation.

The text of this standard is based on the following documents:

FDIS	Report on voting
45B/598/FDIS	45B/606/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61577 series, under the general title *Radiation protection instrumentation – Radon and radon decay product measuring instruments*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

Radon is a radioactive gas produced by the decay of ^{226}Ra , ^{223}Ra and ^{224}Ra , respectively decay products of ^{238}U , ^{235}U and ^{232}Th which are present in the earth's crust. By decay, radon isotopes (i.e. ^{222}Rn , ^{219}Rn , ^{220}Rn) produce three decay chains, each ending in a stable lead isotope.

NOTE In normal conditions, due to the very short half-life of ^{219}Rn , its activity and the activity of its RnDP¹ are considered negligible compared to the activity of the two other series. Its health effects are therefore not important. Thus in this standard ^{219}Rn and its decay products are not considered.

Radon isotopes and their corresponding short-lived Radon Decay Products (RnDP) (i.e. ^{218}Po , ^{214}Pb , ^{214}Bi , ^{214}Po for ^{222}Rn , and ^{216}Po , ^{212}Pb , ^{212}Bi , ^{212}Po , ^{208}Tl for ^{220}Rn) are of considerable importance, as they constitute the major part of the radiological exposure to natural radioactivity for the general public and workers. In some workplaces, for instance in underground mines, spas and waterworks, the workers are exposed to very significant levels of RnDP. These radionuclides are present in variable quantities in the air, in a gaseous form for the radon isotopes, and as very fine particles for the decay products. It is worthwhile for health physicists to be able to measure with a great accuracy the level of this kind of natural radioactivity in the atmosphere. Because the very particular behaviour of these radioactive elements in the atmosphere and in the corresponding measuring instruments, it is necessary to formalize the way such instruments could be tested.

Remark:

In order to facilitate its use, the IEC 61577 series is divided into the following different parts:

IEC 61577-1: This emphasizes the terminology and units of the specific field of radon and radon decay products (RnDP) measurement techniques and presents briefly the concept of System for Test Atmospheres with Radon (STAR) used for test and calibration of radon and RnDP measuring devices.

IEC 61577-2: This part is dedicated to the tests of ^{222}Rn and ^{220}Rn measuring instruments.

IEC 61577-3: This part is dedicated to the tests of RnDP_{222} and RnDP_{220} measuring instruments.

IEC 61577-4: Details how a STAR is constructed and how it can be used for testing.

¹ RnDP is the acronym of Radon Decay Products and it is equivalent to Radon Progeny (see [1] in the Bibliography).

RADIATION PROTECTION INSTRUMENTATION – RADON AND RADON DECAY PRODUCT MEASURING INSTRUMENTS –

Part 4: Equipment for the production of reference atmospheres containing radon isotopes and their decay products (STAR)

1 Scope and object

The IEC 61577 series covers the general features concerning test and calibration of radon and radon decay products measuring instruments. It is also intended to help define type tests, which have to be conducted in order to qualify these instruments. These type tests are described in IEC 61577-2 and IEC 61577-3. This standard addresses only the instruments and associated methods for measuring isotopes 220 and 222 of radon and their subsequent short-lived decay products in gases.

IEC 61577-4 concerns the System for Test Atmospheres with Radon (STAR) needed for testing, in a reference atmosphere, the instruments measuring radon and RnDP. The clauses that follow do neither claim to solve all the problems involved in the production of equipment for setting up reference atmospheres for radon and its decay products, nor to describe all the methods for doing so. They do however set out to be a guide enabling those faced with such problems to choose the best methods for adoption in full knowledge of the facts.

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.

IEC 60050-111:1996, *International Electrotechnical Vocabulary (IEV) – Chapter 111: Physics and chemistry*

IEC 60050-393:2003, *International Electrotechnical Vocabulary (IEV) – Part 393: Nuclear instrumentation – Physical phenomena and basic concepts*

IEC 60050-394:2007, *International Electrotechnical Vocabulary (IEV) – Part 394: Nuclear instrumentation – Instruments, systems, equipment and detectors*

IEC 61577 (all parts), *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures*

ISO/IEC Guide 99:2007, *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ICRP 32: *Annals of the ICRP, Publication N° 32, Limits for inhalation of Radon Daughters by Workers, Vol. 6, N°1, 1981, Pergamon Press*

ICRP 38: *Annals of the ICRP, Publication N° 38, Radionuclides transformations, Energy and Intensity of Emissions, Vol. 11 - 13, 1983, Pergamon Press*

ICRP 65: *Annals of the ICRP, Publication N° 65, ICRP Publication 65: Protection Against Radon-222 at Home and at Work, Vol. 23/2, 1994, Pergamon Press*

3 Terms, definitions and units

For the purposes of this document, the following terms, definitions and units apply.

Throughout the whole standard, the term RADON is used to denote all the radon isotopes, which are covered by this standard. When a particular isotope is to be referred to, it will be indicated by its chemical symbol preceded by its mass number (e.g. ^{220}Rn , ^{222}Rn). For historical reasons, ^{220}Rn is also called thoron.

The term RADON DECAY PRODUCTS or its abbreviation (RnDP) denotes the whole set of short-lived decay products, which are concerned by this standard. A particular isotope is indicated by its chemical symbol preceded by its mass number. The subscripts 222 , 220 added to the symbol RnDP refer to the whole set of short-lived decay products of the corresponding radon isotope (^{218}Po , ^{214}Pb , ^{214}Bi , ^{214}Po), (^{216}Po , ^{212}Pb , ^{212}Bi , ^{212}Po , ^{208}Tl).

All the nuclear data used in this standard refers to ICRP 38, as this standard applies mainly to instruments used for radiation protection purposes.

3.1 General terms and definitions

3.1.1 activity

A

quotient, for an amount of radionuclide in a particular energy state at a given time, of dN by dt , where dN is the expectation value of the number of spontaneous nuclear transitions from this energy state in the time interval of duration dt :

$$A = \frac{dN}{dt}$$

NOTE This quantity is expressed in becquerels (Bq).

[IEV 393-14-12]

3.1.2 volumic activity activity concentration

C_A

quotient of the activity by the total volume of the sample

NOTE 1 For a gas, it is necessary to indicate the temperature and pressure conditions for which the volumic activity, expressed in becquerel per cubic metre, is measured, for example standard temperature and pressure (STP).

NOTE 2 This quantity is expressed in becquerels per cubic metre ($\text{Bq}\cdot\text{m}^{-3}$).

[IEV 393-14-16]

3.1.3 primary standard

standard that is designed or widely acknowledged as having the highest metrological qualities and whose value is accepted without reference to other standards of the same quantity

NOTE The concept of primary standard is equally valid for base quantities and derived quantities.

[VIM, 5.4, modified]