IEC 62302

Edition 1.0 2007-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Radiation protection instrumentation – Equipment for sampling and monitoring radioactive noble gases

Instrumentation pour la radioprotection – Matériel pour le prélèvement et la surveillance des gaz rares radioactifs

IEC 62302:2007

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE
CODE PRIX X

ICS 13.280

ISBN 2-8318-9315-1

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

RADIATION PROTECTION INSTRUMENTATION – EQUIPMENT FOR SAMPLING AND MONITORING RADIOACTIVE NOBLE GASES

FOREWORD

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International Standard IEC 62302 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation.

This standard directly complements IEC 60761-1 (2002) and IEC 60761-3 (2002).

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

FDIS	Report on voting
45B/550/FDIS	45B/556/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.

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- withdrawn,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.

RADIATION PROTECTION INSTRUMENTATION – EQUIPMENT FOR SAMPLING AND MONITORING RADIOACTIVE NOBLE GASES

1 Scope and object

This International Standard is applicable to equipment used for sampling and continuous measurement of radioactive noble gases in the workplace, in gaseous effluents discharged into the environment as well as in the environment itself. Monitoring by definition is the process of continuous and real-time measurement. The processes of sampling or taking samples for retrospective laboratory analysis are included in this standard.

The object of this standard is to establish mandatory general requirements and to present examples of acceptable methods and equipment for sampling and monitoring radioactive noble gases. Current standard IEC 60761-3 which is complemented by this standard, is applicable to installing portable and transportable equipment for sampling and monitoring radioactive noble gases, ONLY IN GASEOUS EFFLUENTS, while this standard expands coverage to include monitoring all possible locations where radioactive noble gases could present a radiological hazard. The equipment is designed to be operational during normal operation conditions as well as under emergency conditions, both during and following an accident. Depending on the nature of the emergency conditions it may be necessary to install specially designed equipment for normal operational conditions and other equipment for emergency conditions.

This standard is applicable to radioactive noble gas samplers and monitors intended to provide the following functions:

– The measurement of the volumetric activity of radioactive noble gases and their variation with time in the workplace, in gaseous effluents at the discharge point and in the environment.

– The measurements performed during normal operational conditions as well as under emergency conditions during and after an accidental release.

– The actuation of an alarm when a predetermined volumetric activity, or concentration, or a predetermined total of released radioactivity is exceeded.

– The determination of the total gaseous activity discharged over a given time and/or to provide information on the composition of a mixture of different gases released.

– The sampling and retrospective analysis of air or gas containing noble gas.

Radon, with isotopes ^{219}Rn, ^{220}Rn, and ^{222}Rn, is a naturally occurring radioactive noble gas whose measurements are NOT considered in this standard. The presence of radon and its progeny may significantly interfere with the proper measurement of the noble gases of concern in this standard.

This standard specifies the general characteristics, general testing procedures, mechanical, electrical and electronic, radiological, safety and environmental characteristics, and the proper identification and certification of the equipment. If this equipment is part of a centralized system for continuous radiation monitoring in a nuclear facility, there may be additional requirements from other standards related to those systems.

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

IEC 60068 (all parts), *Environmental testing*

IEC 60761-1:2002, *Equipment for continuous monitoring of radioactivity in gaseous effluents – Part 1: General requirements*

IEC 60761-3:2002, *Equipment for continuously monitoring radioactivity in gaseous effluents – Part 3: Specific requirements for radioactive noble gas monitors*

IEC 61000 (all parts): *Electromagnetic compatibility (EMC)*

IEC 61187:1993, *Electrical and electronic measuring equipment – Documentation*

ISO Guide 98:1995, *Guide to the expression of uncertainty in measurement (GUM)*

3 Terms and definitions

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

3.1
acceptance test
contractual test to prove to the customer that the system meets certain conditions of its specification

3.2
accident conditions
conditions deviating from normal operations, more severe than anticipated operational occurrences, including design basis accidents and severe accidents

3.3
alarm assembly
assembly or a combination of assemblies whose output provides audible or visual alarm in the event that an alarm threshold has been exceeded or a malfunction has been detected

3.4
anticipated operation occurrence
operational process deviating from normal operation which is expected to occur at least once during the operational lifetime of a nuclear power plant but which, in view of appropriate design provisions, does not cause any significant damage to items important to safety or lead to accident conditions

3.5
coefficient of variation
the ratio V of the standard deviation s to the arithmetic mean $\bar{x}$ of a set of n measurements x_i given by the following formula:

$$V = \frac{s}{\bar{x}} = \frac{1}{\bar{x}}\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2}$$

3.6
collection efficiency
where applicable, the collection efficiency of a monitor is defined as the ratio of the total activity available for measurement on or in the collection medium to the total activity in the air at the inlet of the collection medium

3.7
control assembly
assembly used to process the output of the detection assembly and to provide data indication and electrical power for the entire system

3.8
conventionally true activity
the best estimate of the activity of a radioactive source

NOTE Conventional activities, in general, are regarded as sufficiently close to the true values for the difference to be insignificant for the given purpose. For example, a value and its uncertainty determined from a primary or a secondary standard, or by a reference instrument which has been calibrated against a primary or secondary standard, may be taken as the conventionally true value.

3.9
coverage factor
numerical factor (k) used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty (ISO GUM: 1995)

3.10
decision quantity
random variable used to determine whether a physical effect to be measured is present or not

3.11
decision threshold
fixed value of the radioactivity that allows a decision to be made for each measurement with a given probability of error as to whether the registered measurement includes a contribution from the physical effect

NOTE The statistical test shall be designed such that the probability of wrongly rejecting the hypothesis is equal to a designation α. For this standard error of the first type, α is equal to 5 %.

3.12
design basis accident
accident conditions for which a nuclear power plant is designed according to established design criteria, and for which the damage of the fuel and the release of radioactive material are kept within authorized limits

3.13
detection limit
minimum value of the measurement quantifying a physical effect that can be detected with a given probability of error by the measuring method.

NOTE The detection limit is the smallest true value of the measured value that is associated with the statistical test and hypotheses (Cf. decision quantity) by the following characteristics: if in reality the true value is equal to or exceeds the detection limit, the probability of wrongly not rejecting the hypothesis (error of the second kind) shall be at most equal to a given value β. For this standard ß equals 5 %.

3.14
dynamic range
ratio of the signal from the maximum measurable indication to the signal from the minimum detectable value of that quantity

3.15
effective range of measurement
range of values of the radioactive quantity to be measured over which the performance of equipment or an assembly meets the requirements of its specifications

3.16
error of indication
difference between the indicated value ν of an activity and the conventionally true value ν_c of that activity at the point of measurement

$$\Delta\nu = \nu - \nu_c$$

where:

ν is the value of the activity indicated by the equipment or assembly under test;

ν_c is the conventionally true value of the activity.

3.17
installed equipment
equipment designed to be in place for many years. IEC 60050-393 specifies the “installed life” of such equipment as less than 40 years

3.18
maintenance test
test carried out periodically on a device or equipment to ascertain and, if necessary, make certain adjustments to ensure that its performance remains within specified limits

3.19
manufacturer and purchaser

the term "manufacturer" includes the designer and the seller of the equipment;

the term "purchaser" includes the user of the equipment.

3.20
measurement assembly
this assembly includes functional units designed to measure quantities related to ionizing radiation (activity, volumetric activity, etc.)

3.21
measurement uncertainty
parameter associated with the result of a measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurement. Any result of measurement shall be given with the associated uncertainty calculated following method recommended in the ISO GUM: 1995

3.22
monitor air circuit efficiency
the air circuit efficiency of the monitor describes the losses of activity on the walls of the monitor between the air circuit inlet and the collection medium. It is defined as the ratio of the total activity available for the monitor to sample to the total activity in the air supplied at the inlet of the monitor.

3.23
monitor sampling efficiency
monitor sampling efficiency is defined as the ratio of the volumetric activity as available for measurement on or in the collection medium, to the volumetric activity in the air supplied to the inlet of the monitor. It is the product of the collection efficiency times the air circuit efficiency of the monitor.

3.24
noble gas
the radioactive noble gases of concern in this standard include ^{41}Ar, ^{85}Kr, ^{133}Xe and ^{135}Xe in the workplace, in gaseous effluents and in the environment itself. The isotopes of Radon are NOT included.

3.25
normal operation conditions
operation within specified limits and conditions

3.26
portable equipment
equipment designed to be easily carried by one person to a location where a measurement is required or desired

3.27
radiation detection assembly
assembly or combination of assemblies capable of providing radiation measurements

3.28
reference response
the reference response R_{ref} is the ratio under standard test conditions, between the response indication of the monitor and the unit reference activity (Table 1). This response is expressed by the relation:

$$R_{ref} = \frac{\nu}{\nu_c}$$

where:

ν is the value of the activity measured by the equipment or assembly under test;

ν_c is the conventionally true value of the activity.

3.29
relative intrinsic error
relative error of indication (e_i) of a piece of equipment or an assembly with respect to a quantity when subjected to a specified reference quantity under specified reference conditions expressed as:

$$e_i = \frac{\nu - \nu_c}{\nu_c}.$$

3.30
response time
time required after a step variation in the measured quantity for the output signal variation to reach a given percentage for the first time, usually 90 %, of its final value

NOTE In this standard, 90 % is used.

3.31
retention capacity
the maximum quantity of a defined substance that can be retained at equilibrium in the medium considered

3.32
routine test
a test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria

3.33
sampling assembly
a set of connected devices used to collect a representative gas or air sample

3.34
severe accident
accident conditions more severe than a design basis accident involving significant core degradation

3.35
surface emission rate of a solid source
number of particles of a given type above a given energy that are emerging from the front face of a source per unit time

NOTE This normally applies to alpha and beta emitting sources and not to photon sources, characterized by activity (refer to 7.2.1).

3.36
transportable equipment
equipment designed to be in place for a limited time and capable of being transported to other locations for measurements

3.37
type test
a test of one or more devices made to a certain design to show that the design meets certain specifications

3.38
sensitivity
ratio of the variation of the observed variable to the corresponding variation of the measured quantity, for a given value of the measured quantity

3.39
volumetric activity
radioactivity per unit volume of measured air or gas

4 Classification of noble gas monitoring equipment

There are a number of designs for noble gas monitors available with some monitors of special design to meet the specific needs of the user. This standard classifies noble gas monitors based on the following radiological requirements:

– Gamma detection (best applied to monitoring for ^{41}Ar)
– Beta detection
– Combination beta/gamma detection
– Radionuclide-specific (again applied to monitoring for ^{41}Ar)

• Measurement range

– Low range monitors include those monitors that have range (R) 0 < R < 10 MBq/m^3.
– High range monitors have a range X < R < Y where “X” and “Y” are, respectively, the minimum and the maximum responses of the monitor as stated by the manufacturer.

• Working condition