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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Radiation protection instrumentation – Equipment for monitoring airborne tritium

Instrumentation pour la radioprotection – Matériel pour la surveillance du tritium atmosphérique

IEC 62303:2008

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RADIATION PROTECTION INSTRUMENTATION – EQUIPMENT FOR MONITORING AIRBORNE TRITIUM

FOREWORD

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International Standard IEC 62303 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation.

This standard cancels and replaces the first edition of IEC 60710, published in 1981.

This standard directly complements IEC 60761-1 (2002) and IEC 60761-5 (2002).

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

FDIS	Report on voting
45B/593/FDIS	45B/599/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- withdrawn,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 MONITORING AIRBORNE TRITIUM

1 Scope and object

This International Standard is applicable to equipment used for sampling and continuous measurement of tritium in the workplace, in gaseous effluents discharged into the environment as well as in the environment itself and it is applicable to installed, portable and transportable equipment.

The object of this International Standard is to establish mandatory general requirements and to present examples of acceptable methods and equipment for continuously monitoring and/or sampling airborne tritium. The current standard IEC 60761-5 which is complemented by this standard, is applicable to equipment for sampling and monitoring tritium only in gaseous effluents, while this standard expands coverage to include monitoring all possible locations where tritium could present a radiological hazard. The equipment is designed to be in operation during normal operation conditions as well as under emergency conditions, both during and following an accident. Depending of the emergency conditions, it might be necessary to install specially designed equipment for normal operation conditions and other equipment for emergency conditions.

This International Standard is applicable to tritium samplers and tritium monitors intended to provide the following functions:

– the measurement of the volumetric activity of tritium and its variation with time in the workplace, in gaseous effluents at the discharge point and in the environment;
– the actuation of an alarm when a predetermined volumetric tritium activity or tritium concentration or a predetermined total activity of released tritium is exceeded;
– the determination of the total tritium activity discharged over a given time;
– the sampling and analysis of air or gas containing tritium.

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) – 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 60068 (all parts), *Environmental testing*

IEC 60068-2-27, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock* (*Basic safety publication*)

IEC 60068-2-38, *Environmental testing – Part 2-38: Tests – Test Z/AD:Composite temperature/humidity cyclic test*

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

IEC 60761-5, *Equipment for continuous monitoring of radioactivity in gaseous effluents – Part 5: Specific requirements for tritium monitors*

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

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-11, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-12, *Electromagnetic compatibility (EMC) – Part 4-12: Testing and measurement techniques – Ring wave immunity test*

IEC 61000-6-4, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

IEC 61000-6-6, *Electromagnetic compatibility (EMC) – Part 6-6: Generic standards – HEMP immunity for indoor equipment*

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

ISO 2889 *General principles for sampling airborne radioactive materials*

ISO 10012:2003, *Measurement management systems – Requirements for measurement processes and measuring equipment*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions concerning detection and measurement of ionizing radiation and nuclear instrumentation given in IEC 60050-393, IEC 60050-394, as well as the following, apply.

3.1
accident conditions
substantial deviations from operational states that are expected to be infrequent and which could lead to release of unacceptable quantities of radioactive materials if the relevant engineered safety features did not function as per design intent

3.2
alarm assembly
assembly or a combination of assemblies that provides audible or visual alarm output in the event of an alarm threshold being exceeded or a malfunction being detected

3.3
anticipated operational occurrence
all operational processes deviating from normal operation which are expected to occur once or several times during the operating life of the plant and which, in view of appropriate design provisions, do not cause any significant damage to items important to nuclear safety nor lead to accident conditions

3.4
coefficient of variation
the ratio V of the standard deviation s to the arithmetic mean $\overline{x}$ of a set of n measurements x_i given by the following formula:

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

3.5
control assembly
the assembly used to process the output of the detection assembly and provide indication and power supply for the whole system

3.6
conventionally true activity
the best estimate of the activity of a radioactive source

NOTE Conventionally true activities are, in general, regarded as sufficiently close to the true value 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.

3.7
coverage factor
numerical factor (k) used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty (GUM)

3.8
decision quantity
random variable for the decision whether the physical effect to be measured is present or not

3.9
decision threshold
fixed value of the decision quantity by which, when exceeded by the result of an actual measurement of an measurand quantifying a physical effect, one decides that the physical effect is present

NOTE The statistical test should be designed such that the probability of wrongly rejecting the hypothesis (error of the first kind) is equal to a given value α. For this standard, α equals 5 %.

3.10
design basis accident
set of accident conditions against which a facility is designed according to established design criteria, and for which the damage to the nuclear fuel and the release of radioactive material are kept within authorized limits

3.11
detection limit
smallest true value of the measurand which is detectable by the measuring method

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

3.12
dynamic range
quotient of the signal from the maximum measurable indication of a quantity by the signal from the decision threshold of that quantity

3.13
effective range of measurement
range of the values of the activity to be measured over which the performance of a piece of equipment or an assembly meets the requirements of its specifications

3.14
error of indication
difference between the indicated value ν of a quantity and the conventionally true value ν_c of that quantity at the point of measurement

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

where

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

ν_c is the conventionally true value of the quantity

3.15
manufacturer
the term "manufacturer" includes the designer and the seller of the equipment

3.16
measurement assembly
this assembly includes functional units designed to measure quantities related to ionizing radiation (activity, volumetric activity, etc.)

3.17
measurement uncertainty
parameter, associated with the result of a measurement, that characterises the dispersion of the values that could reasonably be attributed to the measurand. Any result of a measurement should be given with the associated uncertainty calculated following the method recommended in the GUM

3.18
normal operation
operation of a nuclear facility within specified operational limits and conditions

3.19
purchaser
the term "purchaser" includes the user

3.20
radiation detection assembly
assembly designed to produce a signal in response to incident ionising radiation

NOTE 1 This signal carries information about physical properties of the radiation.

NOTE 2 One or more sub-assemblies may be included in the same unit.

3.21
reference response
response of the assembly under reference conditions to a reference volumetric activity. This reference response is expressed as:

$$R_{\mathrm{ref}} = \frac{V}{V_{\mathrm{c}}}$$

where

v is the value measured by the the equipment or assembly under test; and

v_{c} is the conventionally true value of the reference source.

NOTE The background value may be automatically taken in account by an algorithm included in the measuring system.

3.22
relative error
error of the measurement divided by a true value of the measurand

NOTE Since a true value cannot be determined, in practise a conventionally true value is used.

3.23
response time (of a measuring assembly)
duration between the instant of a step change in the measured quantity and the instant when the output signal reaches for the first time as specified percentage of its final value, that percentage being usually taken as 90 %

NOTE For this standard, 90 % is used.

3.24
retention capacity
the maximum quantity of a defined substance which can be retained at equilibrium in the medium considered

3.25
sampling assembly
set of connected devices used to collect a representative sample

3.26
sampling collection efficiency
for a given quantity of radioactive material, ratio of the collected activity to the supplied activity, for a specified time interval

3.27
sensitivity
for a given value of the measured quantity, ratio of the variation of the observed variable to the corresponding variation of the measured quantity

3.28
severe accident
set of accident conditions more severe than those of a design basis accident and involving significant core degradation

3.29
tritium
unless otherwise stated, ”tritium”, in this standard, covers tritium in gaseous or vapour forms, whether chemically combined or not

3.30
tritium monitor
equipment designed for the monitoring of airborne tritium in gaseous effluent discharged to the environment, in the environment and in the atmosphere of a workplace.

3.31
tritium sampler
equipment designed to collect a sample of tritium in any form for subsequent analysis.

3.32
volumetric activity
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 volumetric activity, expressed in becquerels per cubic metre, is measured, for example standard temperature and pressure (STP).

NOTE 2 This quantity is expressed in becquerels per cubic metre (Bq/m^3).

4 Classification of tritium monitoring equipment

Various tritium monitor designs are available to meet the specific needs of the user. This standard classifies tritium monitors based on the following operational and usage requirements:

- Selectivity for the chemical form of tritium:
  - *gross* tritium monitors respond to all gaseous or vapour forms of tritium;
  - *selective* tritium monitors are designed to detect a specific chemical form of airborne tritium, for example tritiated water vapour.
- Method of sampling and analysis:
  - *flow-through* methods in which air is drawn through a measuring device with simultaneous detection;
  - *batch (sequential)* methods in which tritium is collected on an adsorber or trap to allow detection.
- Measurement range:
  - *low range* tritium monitors include those monitors that can be used to measure volumetric activity up to 10 MBq/m^3;
  - *high range* monitors are those monitors that can be used to measure volumetric activity in excess of 10 MBq/m^3.
- Working condition:
  - normal operation conditions;
  - emergency conditions.
- System interface:
  - local readout and alarm only;

  - *interfaced* with a centralized system to initiate alarms or indicate operating faults in addition to the local readout and alarm indications.
- Type of installation and/or power source:
  - *installed* or *transportable* tritium monitors primarily operate using mains power, and may have battery backup. Installed monitors typically have outputs that interface the monitor with a centralized radiation monitoring system;
  - *portable* monitors primarily use battery power and are typically carried from location to location for use. They can also use line power through an internal or external converter, and can also have the ability to interface with a centralized system.

4.1 General design considerations

4.2 Methods of detection

This standard does not specify what type or types of radiation detectors may be used to accomplish the performance required.

4.3 Ease of decontamination

Surfaces that are designed to come in contact with radioactivity (e.g., the sampling and detection assemblies) shall be constructed in such a manner that the build-up of contamination is minimized and shall be designed to facilitate decontamination or to make components easily replaceable.

4.4 Considerations for explosive mixtures

In some circumstances, the measured sample may contain an explosive mixture of gases. Where an explosive mixture may exist, the assembly shall be designed to prevent the ignition of the sample.

4.5 Corrosion resistance

Special system designs shall be required to protect sampling and measuring systems from noxious and/or corrosive substances.

4.6 Reliability

All equipment shall be designed to provide reliable performance with unexplained failures kept to a practical minimum.

The manufacturer should provide documentation on the expected operational lifetime of critical components such as, the air pump, the detector, the flow rate measuring device, the batteries etc.

The manufacturer shall specify the frequency of routine maintenance, and fully describe each maintenance procedure. These maintenance requirements should be kept to a practical minimum.

4.7 Capability of operational testing

The purchaser should be provided with the capability to carry out periodic checks for satisfactory operations of the assembly, including calibration and verification of the measurement linearity. These testing components should normally be installed so as to allow the checks to be carried out with the control and measurement assembly.

It shall be possible to check the calibration of the assembly at two representative points on the measurement range.

This check shall be carried out using one or more suitable radioactive sources, as necessary. The measurement linearity may be checked electronically.

4.8 Adjustment and maintenance facilities

All electronic equipment shall have a sufficient number of easily accessible identified test points to facilitate adjustments and fault location. Any special maintenance tools, together with an appropriate maintenance manual shall be supplied.

The design of all equipment shall be such as to facilitate ease of repair and maintenance.

Self-diagnostic features should be available with a display.

4.9 Acoustic noise level of the assembly

Acoustic noise level of the assembly mainly arises from the sampling assembly and more particularly from the operation of the fluid duct system and the resultant vibration.

The manufacturer shall select the components and shall design the assembly so that the acoustic noise level is minimized and consistent with the type of environment for which the assembly is intended.

4.10 Electromagnetic interference

All necessary precautions shall be taken to protect the equipment from the effects of electromagnetic interference either received or emitted by the equipment.

The severity level 3 shall be applied for immunity (IEC 61000 series).

The manufacturer shall specify the electromagnetic emission of the equipment. The emission limits for apparatus covered by this standard are given in Table 1 of the IEC 61000-6-6.

4.11 Mechanical shock

The monitor should be designed to minimize the effects of mechanical shock.

4.12 Measurement characteristics

The electronic assembly should indicate the measured activity in Bq/m^3. Other methods of indication shall be used by agreement between the manufacturer and the purchaser

The manufacturer shall indicate the decision threshold and the effective range of measurement of the equipment. These characteristics shall be described taking into account the reference background level (0,2 μGy/h) and volumetric activity of radon.

4.13 Measurement range

The effective range of the measurement shall be appropriate to the particular application. The lowest detectable concentration for emergency condition tritium monitors shall at least overlap the highest decade of a tritium monitor designed for normal operation conditions.

The highest detectable concentration shall be at least 0,5 decade above the concentration expected during emergency conditions.

The values of the lowest and highest concentration to be monitored shall be agreed upon between the purchaser and the manufacturer.