IEC 61322

Edition 2.0 2020-01

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Radiation protection instrumentation – Installed ambient dose equivalent rate meters, warning and monitoring assemblies for neutrons with energies from thermal to 20 MeV

Instrumentation pour la radioprotection – Débitmètres d'équivalent de dose ambiant, ensembles d'alarmes et moniteurs à poste fixe pour des énergies de neutrons comprises entre l'énergie thermique et 20 MeV

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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FOREWORD

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International Standard IEC 61322 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation.

This second edition cancels and replaces the first edition published in 1994. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) this document has been updated to take account of the requirements of the relevant IEC standards, IEC 60532:2010 and IEC 61005:2014.

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

FDIS	Report on voting
45B/944/FDIS	45B/952/RVD

Full information on the voting for the approval of this document 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 stability 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- withdrawn,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 – INSTALLED AMBIENT DOSE EQUIVALENT RATE METERS, WARNING AND MONITORING ASSEMBLIES FOR NEUTRONS WITH ENERGIES FROM THERMAL TO 20 MeV

1 Scope

This document applies to installed dose equivalent rate meters, warning assemblies and monitors, as defined below. It covers equipment intended to measure neutron radiation in dose equivalent rates in the energy region between thermal and 20 MeV for the purposes of radiation protection.

Assemblies of this type are commonly defined as area radiation monitors. They are normally employed to determine continuously the radiological situation in working areas in which the radiation field may change with time, for example, nuclear power plants, particle accelerators, high-activity laboratories, fuel reprocessing plants, etc., and provide alarms when the radiation field goes outside predetermined limits.

The assemblies considered in this document comprise at least:

– a detector assembly, which may, for example, consist of a detector probe (for thermal neutrons such as BF_3 proportional counter, ^3He proportional counter, $^6LiI(Tl)$ scintillation detector, etc.) and a moderating and absorbing medium surrounding the detector;

– a processing assembly, which may be fitted into a centralized panel, which, in the case of warning assemblies and monitors, provides signal outputs and contacts capable of activating alarm or other trip circuits;

– alternatively, the case when all the processing electronics are placed within the detection unit (so called "smart blocks") may be considered. In this case the functions of the processing assembly will be composed of only the indication, the providing signal outputs and contacts.

This document specifies general characteristics, general test procedures, radiation characteristics, as well as electrical, mechanical, safety, and environmental characteristics, as well as the identification certificate for the assemblies defined in the scope.

Assemblies designed to perform combined functions comply with the requirements pertaining to each of these functions.

This document is not applicable to criticality monitors covered by IEC 60860, or to assemblies intended to give information about operational parameters of nuclear plants for control purposes. This document is not applicable to the operating characteristics of indicating or recording instruments as such (for instance, indicating meters, recorders, etc.). The characteristics of such instruments are in conformity with the general requirements appropriate to them.

This document does not cover hand-held neutron dose (rate) meters and instruments that are covered in IEC 61005.

No tests are specified in this document for performance requirements in pulsed radiation fields. It is understood that an assembly designed to meet this document may not be suitable for use in these fields.

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.

IEC 60050-395:2014, *International Electrotechnical Vocabulary (IEV) – Part 395: Nuclear instrumentation: Physical phenomena, basic concepts, instruments, systems, equipment and detectors*

IEC 60529:1989, *Degrees of protection provided by enclosures – IP Code*

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measuring techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measuring techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-5:2014, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measuring techniques – Surge immunity test*

IEC 61000-4-6:2013, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measuring techniques – Immunity to conducted disturbances induced by radio-frequency fields*

IEC 61000-4-8, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measuring techniques – Power frequency magnetic field immunity test*

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

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

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

ISO 4037-1:2019, *Radiological protection – X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy – Part 1: Radiation characteristics and production methods*

ISO 4037-2:2019, *Radiological protection – X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy – Part 2: Dosimetry for radiation protection over the energy ranges from 8 keV to 1,3 MeV and 4 MeV to 9 MeV*

ISO 4037-3:2019, *Radiological protection – X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy – Part 3: Calibration of area and personal dosemeters and the measurement of their response as a function of energy and angle of incidence*

ISO 8529-1:2001, *Reference neutron radiations – Part 1: Characteristics and methods of production*

ISO 8529-2:2000, *Reference neutron radiations – Part 2: Calibration fundamentals of radiation protection devices related to the basic quantities characterizing the radiation field*

ISO 8529-3:1998, *Reference neutron radiations – Part 3: Calibration of area and personal dosimeters and determination of response as a function of energy and angle of incidence*

ISO 11929 (all parts): *Determination of the characteristic limits (decision threshold, detection limit and limits of the coverage interval) for measurements of ionizing radiation – Fundamentals and application*

ISO 12789-1:2008, *Reference radiation fields – Simulated workplace neutron fields – Part 1: Characteristics and methods of production*

ISO 12789-2:2008, *Reference radiation fields – Simulated workplace neutron fields – Part 2: Calibration fundamentals related to the basic quantities*

3 Terms and definitions, abbreviated terms and symbols, quantities and units

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions, as well as those given in IEC 60050-395 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

NOTE For clarity and text conciseness in this document the term "neutron ambient dose equivalent rate meter" is abbreviated as "neutron dose rate meter". Whenever the term "neutron dose rate meter" appears in this document it is understood that "neutron ambient dose equivalent rate meter" is meant.

3.1.1
neutron fluence
Φ
quotient of dN by da, where dN is the number of neutrons incident on a sphere of cross-sectional area da;

$$\Phi = \frac{\mathrm{d}N}{\mathrm{d}a}$$

Note 1 to entry: The unit of neutron fluence is m^{-2}.

3.1.2
neutron fluence rate
flux density
$\dot{\Phi}$
quotient of dΦ by dt, where dΦ is the increment of neutron fluence in the time interval dt:

$$\dot{\Phi} \cdot \frac{\mathrm{d}}{\mathrm{d}t}$$

Note 1 to entry: The unit of neutron fluence rate is $\mathrm{m}^{-2}\ \mathrm{s}^{-1}$.

3.1.3
ambient dose equivalent
$H^*(10)$
dose equivalent at a point in a radiation field that would be produced by the corresponding aligned and expanded field, in the ICRU sphere at a depth of 10 mm on the radius opposing the direction of the aligned field [1], [2], [3], [4] [1]

Note 1 to entry: An instrument that has an isotropic response and is calibrated in terms of $H^*(10)$ will measure $H^*(10)$ in a radiation field that is uniform over the dimensions of the instrument.

3.1.4
ambient dose equivalent rate
$\dot{H}^*(10)$
ratio of d$H^*(10)$ by dt, where d$H^*(10)$ is the increment of ambient dose equivalent in the time interval dt

$$\dot{H}^*(10) = \frac{\mathrm{d}H^*(10)}{\mathrm{d}t}$$

3.1.5
neutron fluence-to-ambient dose equivalent conversion coefficient
h_Φ
quotient of the neutron ambient dose equivalent, $H^*(10)$, and the neutron fluence, Φ, at a point in the radiation field, undisturbed by the irradiated object

$$h_\Phi = \frac{H^*(10)}{\Phi}$$

Note 1 to entry: The conversion coefficients are given in Annex A.

3.1.6
calibration distance
distance between the reference point of the assembly and the centre of the calibration source

3.1.7
reference point of an assembly
physical or virtual mark or marks on the assembly to be used in order to position it at the test point. This mark is usually either the geometric centre of the detector or its effective centre

Note 1 to entry: Effective reference point of an assembly is located at a distance, stated by a manufacturer for specified energy, from a reference point of the assembly to be used in order to position the assembly at a point where the conventional true value of a quantity to be measured is known.

3.1.8
conventional true value
$\dot{H}_t$
quantity value attributed by agreement to a quantity for a given purpose

Note 1 to entry: In this document the quantity is the dose equivalent rate.

Note 2 to entry: Sometimes a conventional true value is an estimate of a true quantity value.

Note 3 to entry: A conventional true value is generally accepted as being associated with a suitably small measurement uncertainty, which might be zero.

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1 Numbers in square brackets refer to the Bibliography.

3.1.9
indicated value
$\dot{H}_\mathrm{i}$
value given by the (digital) indication of the dose rate meter in unit of dose equivalent rate

3.1.10
neutron dose equivalent response
$\boldsymbol{R_H}$
ratio, under specified conditions, given by the relation

$$R_H = \frac{R_\Phi}{h_\Phi}$$

where

R_Φ is the neutron fluence response (see definition 3.1.11), and

h_Φ is the neutron fluence-to-dose conversion coefficient (see definition 3.1.5).

3.1.11
neutron fluence response
$\boldsymbol{R_\Phi}$
ratio, under specified conditions, given by the relation

$$R_\Phi = \frac{M}{\Phi}$$

where

M is the reading by the instrument under test (doserate meter) for the neutron fluence, and

Φ is the conventional true value of the neutron fluence to which the instrument has been exposed.

Note 1 to entry: The unit of neutron fluence response is m^2.

3.1.12
reference response
$\boldsymbol{R_\mathrm{r}}$
response for a reference value of the quantity to be measured under reference conditions

$$R_\mathrm{r} = \frac{\dot{H}_\mathrm{r}}{\dot{H}_\mathrm{t}}$$

where

$\dot{H}_\mathrm{r}$ is the corresponding indicated value of the quantity to be measured under reference conditions, and

$\dot{H}_\mathrm{t}$ is the conventional true value (3.1.8) under reference conditions

Note 1 to entry: The reference response is the reciprocal of the reference calibration factor.

Note 2 to entry: The reference values for the dose rate are given in Table 1.

3.1.13
relative response
r
quotient of the response R (3.1.11) and the reference response R_r (3.1.12)

$$r = \frac{R}{R_r}$$

3.1.14
response of a radiation measuring assembly
R
ratio, under specified conditions, given by the relation

$$R = \frac{\dot{H}_i}{\dot{H}_t}$$

where

$\dot{H}_i$ is the indicated value of the quantity (3.1.9) measured by the instrument under test, and

$\dot{H}_t$ is the conventional true value of this quantity (3.1.8).

3.1.15
relative error of an indication
I
relative error, I, in the indication of an assembly is given as a percentage, by the relationship:

$$I(\%) = \frac{\dot{H}_i - \dot{H}_t}{\dot{H}_t} \times 100$$

3.1.16
coefficient of variation
v
ratio of the experimental standard deviation s to the arithmetic mean $\bar{\dot{H}}$ of a set of n indications $\dot{H}_j$. It is given by the following formula:

$$v = \frac{s}{\bar{\dot{H}}} = \frac{1}{\bar{\dot{H}}} \cdot \sqrt{\frac{1}{n-1} \cdot \sum_{j=1}^{n} \left(\dot{H}_j - \bar{\dot{H}}\right)^2}$$

3.1.17
effective range of measurement
range of values of ambient dose equivalent rate over which the performance of the ambient dose equivalent rate meter meets the requirements of this document

3.1.18
manufacturer
designer and seller of the equipment

3.1.19
purchaser
user (operator) of the equipment