

Radiation protection instrumentation — Neutron ambient dose equivalent (rate) meters

The European Standard EN 61005:2004 has the status of a
British Standard

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National foreword

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The CENELEC common modifications have been implemented at the appropriate places in the text. The start and finish of each common modification is indicated in the text by tags **[C]** **[C]**.

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**Radiation protection instrumentation –
Neutron ambient dose equivalent (rate) meters
(IEC 61005:2003, modified)**

Instrumentation pour la radioprotection -
Appareils de mesure de l'équivalent
de dose ambient neutron
(ou de son débit d'équivalent de dose)
(CEI 61005:2003, modifiée)

Strahlenschutz-Messgeräte -
Umgebungsäquivalentdosis(leistungs-)
Messgeräte für Neutronenstrahlung
(IEC 61005:2003, modifiziert)

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CENELEC

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Foreword

The text of the International Standard IEC 61005:2003, prepared by SC 45B, Radiation protection instrumentation, of IEC TC 45, Nuclear instrumentation, together with the common modifications prepared by the CENELEC BTTF 111-3, Instrumentation for ionizing radiation measurement and protection, was submitted to the formal vote and was approved by CENELEC as EN 61005 on 2004-10-01.

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Clauses, Subclauses, tables and figures which are additional to those in IEC 61005 are prefixed "Z".

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61005:2003 was approved by CENELEC as a European Standard with agreed common modifications.

CONTENTS

1	Scope and object.....	5
2	Normative references	5
3	Terms and definitions	7
3.1	General	7
3.2	Dosimetric terms and quantities	7
3.3	Definitions	8
3.4	Test nomenclature.....	10
4	General characteristics of the measuring assemblies	11
4.1	Assembly labels and markings	11
4.2	Indication of the assembly	11
4.3	External signal connections	11
4.4	Effective range of measurement	11
5	General test procedures	12
5.1	Test requirements	12
5.2	Tests performed under standard test conditions	12
5.3	Tests performed with variation of influence quantities	12
5.4	Statistical fluctuations	12
5.5	Reference neutron radiation	13
6	Radiation characteristics	13
6.1	Relative intrinsic error in ambient dose equivalent rate indication	13
6.2	Requirements on the accuracy of alarm settings.....	15
6.3	Variation of response with neutron radiation energy	16
6.4	Variation of indication with angle of incidence of radiation	17
6.5	Response in workplace neutron fields	17
6.6	Response to other external ionising radiations	18
7	Electrical characteristics	19
7.1	Statistical fluctuations	19
7.2	Response time	19
7.3	Relationship between response time and statistical fluctuations	20
7.4	Zero drift	20
7.5	Warm-up time.....	21
7.6	Power supplies – battery operation.....	21
7.7	Power supplies – Mains operations	22
8	Electromagnetic compatibility	23
8.1	General	23
8.2	Electrostatic discharge	23
8.3	Radiated electromagnetic fields.....	23
8.4	Conducted disturbances induced by radio-frequencies	25
8.5	Conducted disturbances induced by surges and oscillatory waves.....	25
8.6	Conducted disturbances induced by fast transients or bursts.....	25
8.7	External magnetic fields (50 Hz/60 Hz).....	26
8.8	Emission of electromagnetic radiation	26
9	Mechanical characteristics.....	26
9.1	Mechanical shocks	26
9.2	Orientation of assembly (geotropism)	27
9.3	Vibration test.....	27

10	Safety characteristics	27
10.1	Overload characteristics	27
10.2	Ease of decontamination	28
11	Environmental characteristics	28
11.1	Ambient temperature influence	28
11.2	Temperature shock.....	28
11.3	Relative humidity.....	29
11.4	Atmospheric pressure.....	29
11.5	Sealing.....	30
11.6	Storage and transport.....	30
12	Documentation	30
12.1	Identification certificate	30
12.2	Operation and maintenance manual	30
Annex A (normative)	Neutron fluence-to-ambient dose equivalent conversion coefficients	34
Annex ZA (normative)	Normative references to international publications with their corresponding European publications	36
Figure A.1	– Neutron fluence-to-ambient dose equivalent conversion coefficients for mono-energetic neutrons (data taken from ICRU 57 (1998))	35
Table 1	– Reference conditions and standard test conditions	31
Table 2	– Tests performed under standard test conditions	31
Table 3	– Tests performed with variation of influence quantities.....	32
Table 4	– Limits of variation of performance characteristics due to effects of influence quantities.....	33
Table A.1	– Neutron fluence-to-ambient dose equivalent conversion coefficients for mono-energetic neutrons (data taken from ICRU 57 (1998))	34
Table A.2	– Neutron fluence-to-ambient dose equivalent conversion coefficients for the neutron reference radiation sources (data taken from ICRU 57 (1998) and ISO 8529-3)	35

RADIATION PROTECTION INSTRUMENTATION – NEUTRON AMBIENT DOSE EQUIVALENT (RATE) METERS

1 Scope and object

This International Standard is applicable to all assemblies designed to measure the ambient dose equivalent (rate) due to neutron radiation of energy up to 16 MeV, and which comprise at least:

- a) a detection assembly, which may, for example, consist of a detector probe for thermalised neutrons and an arrangement of moderating and absorbing media surrounding the detector;
- b) a measuring assembly with a display for the measuring result, which may be incorporated into a single assembly or connected by means of a flexible cable.

NOTE Z If the Equipment consists of separate detector and measurement assemblies the cable between the two shall be that specified by the manufacturer. If the connection is by other means (e.g. radio waves, infrared) or other cables, it is necessary to apply additional requirements with respect to the specific media.

The requirements given below pertain to assemblies as defined in the first paragraph. It is acceptable, however, to use assemblies, which do not meet the requirements below when such requirements are not deemed essential for a given purpose. In such cases, the requirements to be applied to the assemblies should be specified by agreement between the manufacturer and the purchaser, but the methods of determination of the characteristics of the assemblies should conform to this standard.

No tests are specified in this standard for the performance requirements of the assemblies in pulsed radiation fields, and it is to be considered that an assembly designed to meet this standard may not be suitable for use in such fields.

The object of this standard is to specify requirements for the performance characteristics of neutron ambient dose equivalent (rate) meters, and to prescribe the methods of testing in order to determine compliance with this standard. This standard specifies, for the assemblies described in the first paragraph, general characteristics, general test procedures, radiation characteristics, electrical, mechanical, safety and environmental characteristics, and also the identification certificate. Requirements and test procedures are also specified for the alarm performance of the dose equivalent (rate) meters, which are equipped with alarm provisions.

NOTE Dose equivalent (rate) meters for neutrons have an energy dependence of ambient dose equivalent response, which may deviate considerably from unity. The response in realistic spectra encountered in workplace fields is such that the deviations in different energy ranges tend to neutralise each other. Consequently, the response in realistic fields is generally much closer to unity.

ISO 12789 specifies a list of appropriate neutron sources having broad spectra suitable for the testing of such (rate) meters. Also work places may be specified by agreement between manufacturer and purchaser to be appropriate for testing when the spectral environment is well defined.

Unconventional dose equivalent ratemeters, for example consisting of more than one detector probe, have recently become available. For such instruments, evaluation based on mono-energetic neutrons is not relevant. Also for those ratemeters, the above considerations may apply.

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 60050-393:1996, *International Electrotechnical Vocabulary – Chapter 393: Nuclear instrumentation: Physical phenomena and basic concepts*

IEC 60050-394:1995, *International Electrotechnical Vocabulary – Chapter 394: Nuclear instrumentation: Instruments*

IEC 60086-1:2000, *Primary batteries – Part 1: General*

IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test*. Basic EMC Publication Amendment 1 (1998)

IEC 61000-4-3:2002, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test*. Basic EMC Publication

IEC 61000-4-5:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 5: Surge immunity test*
Amendment 1 (2000)

IEC 61000-4-6:1996, *Electromagnetic compatibility (EMC)- Part 4: Testing and measurement techniques – Section 6: Immunity to conducted disturbances, induced by radio-frequency fields*
Amendment 1 (2000)

IEC 61000-4-8:1993, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 8: Power frequency magnetic field immunity test*
Amendment 1 (2000)

IEC 61000-4-12:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 12: Oscillatory waves immunity test*
Amendment 1 (2000)

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

ISO 4037-1:1996, *X and gamma reference radiations for calibrating dosimeters and dose rate meters and for determining their response as a function of photon energy – Part 1: Radiation characteristics and production methods*

ISO 4037-2:1997, *X and gamma reference radiations for calibrating dosimeters and dose rate 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 4037-3:1999, *X and gamma reference radiations for calibrating dosimeters and dose rate meters and for determining their response as a function of photon energy – Part 3: Calibration of area and personal dosimeters and the measurement of their response as a function of energy and angle of incidence*

EN 55011:1998, *Industrial, scientific and medical (ISM) radio-frequency equipment – Radiodisturbance characteristics – Limits and methods of measurement*

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 11929-1:2000, *Determination of the detection limit and decision threshold for ionizing radiation measurements – Part 1: Fundamentals and application to counting measurements without the influence of sample treatment*

ISO 12789:2000, *Reference neutron radiations – Characteristics and methods of production of simulated workplace neutron fields*.

ICRP Publication 74:1996, *Conversion Coefficients for Use in Radiological Protection against External Radiation*, Annals of the ICRP Vol. 26, 2/4

ICRU Report 43:1988, *Determination of Dose Equivalents from External Radiation Sources – Part 2*.

ICRU Report 51:1993, *Quantities and Units in Radiation Protection Dosimetry*.

ICRU Report 57:1998, *Conversion coefficients for use in radiation protection against external radiation*.

3 Terms and definitions

3.1 General

The general terminology concerning radiation quantities and dosimetric terms, the detection and measurement of ionising radiation, and nuclear instrumentation is given in IEC 60050-393 and IEC 60050-394. For the purpose of this International Standard, the following definitions apply.

3.2 Dosimetric terms and quantities

NOTE The system of radiation units used in this standard is the SI system. Multiples and sub-multiples of the units are used in accordance with SI. The specific radiation protection quantities and units are used in accordance with ICRU 51 (1993) and ISO 8529-1. In addition, for time, the units hour (h) and minute (min) are used.

3.2.1 fluence m⁻²

quotient of dN by da , where dN is the number of particles which enter a sphere of cross-sectional area da :

$$\Phi = \frac{dN}{da}$$

3.2.2**fluence rate (flux density)****m⁻².s⁻¹**

quotient of $d\Phi$ by dt , where $d\Phi$ is the increment of particle fluence in the time interval dt :

$$\dot{\Phi} = \frac{d\Phi}{dt}$$

3.2.3**ambient dose equivalent**

dose equivalent, $H^*(10)$, 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 (ICRP 74, 1996, ICRU 57, 1998).

NOTE 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.

3.2.4**ambient dose equivalent rate**

quotient of $dH^*(10)$ by dt , where $dH^*(10)$ is the increment of dose equivalent in the time interval dt :

$$\dot{H}^*(10) = \frac{dH^*(10)}{dt}$$

NOTE Units of dose equivalent rate are any quotient of the sievert (Sv) or its multiple or submultiple by a suitable unit of time (Sv.s⁻¹, mSv.h⁻¹, etc.).

3.2.5**fluence-to-ambient dose equivalent conversion coefficient**

ratio of ambient dose equivalent, $H^*(10)$, to fluence, Φ

NOTE The conversion coefficients given in Annex A are taken from ICRU 57 (1998) and used throughout this standard.

3.3 Definitions**3.3.1****neutron ambient dose equivalent (rate) meter**

assembly intended to measure or evaluate the ambient dose equivalent rate from neutron radiation. It may include one or more radiation detectors and associated assemblies or basic function units.

NOTE The assembly may be transportable or portable. For routine use, the radiation detector(s) and associated assemblies may also be mountable in a fixed position.

3.3.2**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.

3.3.3

point of test

point in the radiation field at which the conventional true value of ambient dose equivalent (rate) is known. For all tests involving the use of radiation, the reference point of the assembly is placed at the point of test in the orientation indicated by the manufacturer. An exception is the test of variation in response with angle of incidence.

3.3.4

reference orientation

orientation of the assembly with respect to the direction of the incident radiation during calibration

3.3.5

calibration distance

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

3.3.6

conventional true value of ambient dose equivalent (rate)

best estimate of the true ambient dose equivalent (rate), $H_t^*(10)$, used for calibration of the assembly. This value and its uncertainty are determined from a primary or a secondary standard, or by a reference instrument which has been calibrated against a secondary or a primary standard.

NOTE Primary or secondary standards for neutron radiation are usually standardized in terms of fluence (rate). For converting the fluence (rate) to the conventional true value of the ambient dose equivalent (rate), the appropriate fluence to ambient dose equivalent conversion coefficients given in Annex A shall be used.

3.3.7

indicated ambient dose equivalent rate

value $\dot{H}_i^*(10)$ of the ambient dose equivalent rate as indicated by the measuring assembly under test

3.3.8

ambient dose equivalent response

ratio, R , of the indicated ambient dose equivalent (rate), $H_i^*(10)$, to the conventional true value of the ambient dose equivalent (rate), $H_t^*(10)$:

$$R = \frac{H_i^*(10)}{H_t^*(10)}$$

3.3.9

error of an indication

difference between the indicated ambient dose equivalent (rate), $H_i^*(10)$, and the conventional true value, $H_t^*(10)$, of that quantity at the point of test

3.3.10

relative error of an indication

ratio, I , of the error of an indication to the conventional true value, $H_t^*(10)$:

$$I = \frac{H_i^*(10) - H_t^*(10)}{H_t^*(10)}$$

3.3.11**relative intrinsic error**

relative error of the indication of an assembly subjected to a specified reference radiation, under specified reference conditions

3.3.12**coefficient of variation**

ratio, v , of the experimental standard deviation s to the arithmetic mean $\bar{H}_i$ of a set of n indications H_{ij} . It is given by the following formula:

$$v = \frac{s}{\bar{H}_i} = \frac{1}{\bar{H}_i} \sqrt{\frac{1}{n-1} \cdot \sum_{j=1}^n (H_{ij} - \bar{H}_i)^2}$$

3.3.13**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 standard

3.3.14**nominal range of use**

range of values of an influence quantity or instrument parameter within which the dose equivalent (rate) meter will operate within the limits of variation. Its limits are the maximum and minimum rated values

3.3.15**minimum nominal range of use**

smallest range specified of an influence quantity or instrument parameter over which the dose equivalent (rate) meter operates within the specified limits of variation in order to comply with this standard

3.4 Test nomenclature**3.4.1****qualification tests**

tests, which are performed in order to verify that the requirements of a specification are fulfilled. Qualification tests are subdivided into type tests and routine tests

3.4.2**type tests**

conformity testing on the basis of one or more specimens of a product representative of the production

3.4.3**routine tests**

tests to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria

3.4.4**acceptance tests**

contractual tests to prove to the customer that the device meets certain conditions of its specification

3.4.5

supplementary tests

tests intended to provide supplementary information on certain characteristics of the dose equivalent (rate) meters

4 General characteristics of the measuring assemblies

4.1 Assembly labels and markings

An assembly for the measurement of neutron ambient dose equivalent (rate) shall be labelled with a specific indication of its intended use.

The reference point for an assembly for calibration and test purposes shall be indicated on the outside of the assembly and/or unambiguously described in the documentation.

4.2 Indication of the assembly

The indication of the assembly shall be in units of ambient dose equivalent (rate), for example in millisieverts (per hour). The indication may be on an analogous type of display or on a digital display. It is recommended that the indication may be read remotely.

4.3 External signal connections

The provision of an output connection for a remote readout, which shall be appropriately marked, is recommended (for example for an external counter or integrator, a recorder or a secondary digital display). The following input and output connections, as appropriate for the assembly, are recommended:

- an input connection to the pre-amplifier input for electrical test purposes;
- an output connection from the amplifier;
- an output connection from the discriminator.

If the assembly is equipped with a data processor and memory, an output to an external data device is recommended, for example by a serial data interface.

4.4 Effective range of measurement

The effective range of measurement shall cover at least four orders of magnitude of ambient dose equivalent rate, normally from $1 \mu\text{Sv}\cdot\text{h}^{-1}$ to $10 \text{ mSv}\cdot\text{h}^{-1}$. Measurement at higher ambient dose equivalent rates, up to $100 \text{ mSv}\cdot\text{h}^{-1}$, may be required and this shall be incorporated by agreement between purchaser and manufacturer.

The effective range of measurement shall not be less than the following:

- a) For assemblies with an analogue type of display (linear or logarithmic), from 10 % to 100 % of the scale maximum angular deflection on each scale range.
- b) For assemblies with a digital display, from the first non-zero indication in the second least significant digit up to the maximum indication on each range. () As an example, for a display with a maximum indication of 99,9, the effective range shall extend from 1,0 to 9,99 ().

It is recommended that instruments with a digital display be provided with an integrating facility to measure lower dose ambient equivalent rates. If an integrating facility is provided, the user shall be capable of selecting multiple integrating times of not less than 1 min.

NOTE The integration time refers to devices where pulses are counted during that time and the indication calculated from the number of counts.