SLOVENSKI STANDARD
SIST EN 62387-1:2012

01-maj-2012

Instrumenti za zaščito pred sevanjem - Pasivni integrirni dozimetrijski sistemi za okoljsko in osebno nadzorovanje - 1. del: Splošne značilnosti in tehnične zahteve

Radiation protection instrumentation - Passive integrating dosimetry systems for environmental and personal monitoring - Part 1: General characteristics and performance requirements

Strahlenschutz-Messgeräte - Passive, integrierende Dosimetriesysteme zur Umwelt- und Personenüberwachung - Teil 1: Allgemeine Eigenschaften und Leistungsanforderungen

Instrumentation pour la radioprotection - Systèmes dosimétriques intégrés passifs pour la surveillance de l'environnement et de l'individu - Partie 1: Caractéristiques générales et exigences de fonctionnement

Ta slovenski standard je istoveten z: **EN 62387-1:2012**

ICS:

13.280	Varstvo pred sevanjem	Radiation protection

SIST EN 62387-1:2012 **en,fr,de**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 62387-1

February 2012

ICS 13.280

English version

Radiation protection instrumentation - Passive integrating dosimetry systems for environmental and personal monitoring - Part 1: General characteristics and performance requirements

(IEC 62387-1:2007, modified)

Instrumentation pour la radioprotection - Systèmes dosimétriques intégrés passifs pour la surveillance de l'environnement et de l'individu - Partie 1: Caractéristiques générales et exigences de fonctionnement (CEI 62387-1:2007, modifiée)

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CENELEC

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Foreword

This document (EN 62387-1:2012) consists of the text of IEC 62387-1:2007 prepared by IEC/SC 45B, "Radiation protection instrumentation", of IEC/TC 45, "Nuclear instrumentation", together with the common modifications prepared by CLC/TC 45B, "Radiation protection instrumentation".

The following dates are fixed:

- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2013-01-02
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2015-01-02

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Clauses, subclauses, notes, tables, figures and annexes which are additional to those in IEC 62387-1:2007 are prefixed “Z”.

In this document, the common modifications to IEC 62387-1:2007 are indicated by a vertical line in the left margin of the text.

The main objectives of EN 62387-1 are to

- specify performance requirements for complete dosimetry systems including detectors, dosemeters, readers, and additional equipment. In addition, the corresponding methods of test to check that these requirements are met are given in detail,
- harmonize requirements for all types of passive dosimetry systems detecting external photon and beta radiation,

- specify the use the operational quantities according to ICRU 51,
- harmonize tests using radiation with relevant ISO standards on reference radiation and calibration: ISO 4037 for photon radiation, ISO 6980 for beta radiation and ISO 8529 for neutron radiation. For this reason, no conversion coefficients from air kerma (or absorbed dose or fluence) to the operational quantities are given in this standard, except in case the necessary conversion coefficients are not included in the respective ISO standard. Those given in the ISO-standards are applicable,
- incorporate basic terms of the concept that a result of a measurement essentially consists of a value and an associated uncertainty, as laid down in the introductions of IEV 311 and EN 60359 and refer the reader to an IEC technical report for complete uncertainty analysis in radiation protection measurements and to the GUM,
- align CENELEC performance requirements on dosimetry systems for measuring personal dose equivalents with the recommendations on accuracy stated in the ICRP Publication 75: *General Principles for the Radiation Protection of Workers*. Further information is given in the informative Annex ZB.

Introduction

A dosimetry system may consist of the following elements:

a) a passive device, referred to here as a *detector*, which, after the presence of radiation, provides and stores a signal for use in measuring one or more quantities of the incident radiation field;

b) a *dosemeter*, that incorporates some means of identification and contains one or more detectors;

c) a *reader* which is used to readout the stored information (signal) from the detector, in order to determine the radiation dose;

d) a *computer* with appropriate *software* to control the reader, store the signals transmitted from the reader, calculate, display and store the evaluated dose in the form of an electronic file or paper copy;

e) *additional equipment* and documented procedures (instruction manual) for performing associated processes such as deleting stored dose information, cleaning dosemeters, or those needed to ensure the effectiveness of the whole system.

1 Scope and object

This European Standard applies to all kinds of passive dosimetry systems that are used for measuring

- the personal dose equivalent $H_p(10)$ (for whole body dosimetry),
- the personal dose equivalent $H_p(0,07)$ (for both whole body and extremity dosimetry),or
- the ambient dose equivalent $H^*(10)$ (for environmental dosimetry).

It applies to dosimetry systems that measure external photon or beta radiation in the dose range between 0,01 mSv and 10 Sv and in the energy ranges given in the following Table. All the energy values are mean energies with respect to the prevailing dose quantity. The dosimetry systems usually use electronic devices for the data evaluation and thus are often computer controlled.

Measuring quantity	Mandatory energy range for photon radiation	Maximum energy range for testing photon radiation	Mandatory energy range for beta-particle radiation	Maximum energy range for testing beta-particle radiation
$H_p(10)$, $H^*(10)$	80 keV to 1,25 MeV	12 keV to 7 MeV	---	---
$H_p(0,07)$	30 keV to 250 keV	8 keV to 7 MeV	0,8 MeV almost equivalent to an E_{max} of 2,27 MeV	0,07 MeV[a] to 1,2 MeV almost equivalent to E_{max} from 0,225 MeV to 3,54 MeV

[a] For beta-particle radiation, an energy of 0,07 MeV is required to penetrate the dead layer of skin of 0,07 mm (almost equivalent to 0,07 mm of ICRU tissue).

NOTE 1 In this standard, “dose” means personal or ambient dose equivalent, unless otherwise stated.

NOTE 2 For $H_p(10)$ and $H^*(10)$ no beta radiation is considered. Reasons: 1) $H_p(10)$ and $H^*(10)$ are a conservative estimate for the effective dose which is not a suitable quantity for beta radiation. 2) No conversion coefficients are available in ICRU 56, ICRU 57 or ISO 6980.

NOTE 3 The maximum energy ranges are the energy limits within which type tests according to this standard are possible.

In addition, this standard can be applied for testing neutron dosimetry systems concerning the design (Clause 8), the instruction manual (Clause 9), the software (Clause 10), environmental influences (Clause 13), electromagnetic influences (Clause 14), mechanical influences (Clause 15), and the documentation (Clause 16). The test utilizing radiation (Clauses 13 to 15) shall be done with neutron reference radiation qualities according to the ISO 8529 series.

In some countries the presence of beta dose has to be indicated by dosemeters worn on the trunk. Such an indication of the presence of beta dose is not a measurement. For that reason, a specific subclause (11.8) deals with the indication of the presence of beta dose.

This standard is intended to be applied to dosimetry systems that are capable of evaluating doses in the required quantity and unit (Sv) from readout signals in any quantity and unit. The only correction that may be applied to the evaluated dose (indicated value) is the one resulting from natural background radiation using extra dosemeters.

NOTE 4 The correction due to natural background may be made before or after the dose calculation.

Usually, a dosimetry system is not able to measure all quantities given above. Thus, the systems shall only be tested with regards to those quantities and types of radiation it is intended to be used for. Annex D gives further guidelines to define specific usage categories.

Full compliance with this standard is given if the requirements for the mandatory ranges given in Tables 3 to 5 are fulfilled. If the customer or manufacturer requires extended ranges then the test should also be performed as specified in this standard, i.e. the requirements given in Tables 3 to 5 apply, too. The range of any influence quantity stated by the manufacturer is called rated range. Thus, dosimetry systems can be classified by stating a set of ranges (for example, for dose, for energy, for temperature) within which the requirements stated in this standard are met (Capabilities of the system, see Clause 7). In addition, usage categories are given in Annex D with respect to different measuring capabilities.

For the dosimetry systems described above, this standard specifies general characteristics, general test procedures and performance requirements, radiation characteristics as well as environmental, electrical, mechanical, software and safety characteristics.

A dosimetry system may be tested with regards to different quantities at different times. In case the dosimetry system was changed since the previous test, a new test with regards to quantities tests formerly may be necessary.

The absolute calibration of the dosimetry system is not checked during a type test according to this standard as only system properties are of interest. The absolute calibration is checked during a routine test.

2 Normative references

For normative references, see the normative Annex ZA.

3 Terms and definitions

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

For definitions related to measurements in general, definitions were taken from IEC 60050-300, Part 311, from IEC 60050-393 and from IEC 60050-394. A very limited number of definitions was taken from ISO 4037-3 and the ISO Guide to the Expression of Uncertainty in Measurement (GUM).

The references are given in brackets [ ]. The information following the brackets is specific to this standard and is not originating from the given source.

A word between parentheses ( ) in the title of a definition is a qualifier that may be skipped if there is no danger of confusion with a similar term.

The terms are listed in alphabetical order.

3.1
ambient dose equivalent
***H**(*d*)**
at a point in a radiation field, dose equivalent that would be produced by the corresponding expanded and aligned field, in the ICRU sphere at a depth, *d*, on the radius opposing the direction of the aligned field

[SOURCE: ICRU 51]

Note 1 to entry: The recommended depth, d, for environmental monitoring in terms of $H^*(d)$ is 10 mm, and $H^*(d)$ may be written as $H^*(10)$. [IEV 393-14-95]

3.2
calibration factor
***N*$_0$**
quotient of the conventional true value of a quantity $C_{r,0}$ and the indicated value $G_{r,0}$ at the point of test for a reference radiation under reference conditions. It is expressed as

$$N_0 = \frac{C_{r,0}}{G_{r,0}}$$

Note 1 to entry: The reciprocal of the calibration factor is equal to the response under reference conditions. In contrast to the calibration factor, which refers to the reference conditions only, the response refers to any conditions prevailing at the time of measurement.

[SOURCE: ISO 4037-3, Definition 3.2.12, modified]

Note 2 to entry: This definition is of special importance for non-linear dosemeters.

Note 3 to entry: The reference value $C_{r,0}$ for the dose is given in Table 2.

3.3
coefficient of variation
v
ratio of the standard deviation s to the arithmetic mean $\overline{G}$ of a set of n indicated values G_j (indicated value) given by the following formula:

$$v = \frac{s}{\overline{G}} = \frac{1}{\overline{G}} \sqrt{\frac{1}{n-1} \sum_{j=1}^{n} \left(G_j - \overline{G}\right)^2}$$

[SOURCE: IEV 394-20-14, modified]

3.4
conventional true value (of a quantity)
C
value attributed to a particular quantity and accepted, sometimes by convention, as having an uncertainty appropriate for a given purpose

Note 1 to entry: "Conventional true value" is sometimes called “assigned value”, “best estimate of the value”, “conventional value” or “reference value”.

[SOURCE: GUM B.2.4]

3.5
correction for non-linearity
***r*n**
quotient of the response R_n under conditions where only the value of the dose equivalent is varied, and the reference response R_0. It is expressed as

$$r_n = \frac{R_n}{R_0}$$

Note 1 to entry: For a linear dosimetry system, r_n is equal to unity.

3.6
coverage factor
k
numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty

Note 1 to entry: A coverage factor k is typically in the range 2 to 3.

[SOURCE: GUM 2.3.6]

Note 2 to entry: In case of a normal distribution, using a coverage factor of 2 results in an expanded uncertainty that defines an interval around the result of a measurement that contains approximately 95 % of the distribution of values that could reasonably be attributed to the measurand. For other distributions, the coverage factor may be larger.

3.7
detector
element of equipment or a substance which, in the presence of radiation, provides a signal for use in measuring one or more quantities of the incident radiation

[SOURCE: IEV 394-04-01]

Note 1 to entry: The detector usually requires a separate reader to read out the signal. That means the detector usually is not able to provide a signal without any external reading process.

Note 2 to entry: A passive detector does not need an external power supply to collect and store dose information.

Note 3 to entry: In IEV, the term reads “radiation detector”.

3.8
deviation
D
difference between the indicated values for the same value of the measurand of a dosimetry system, when an influence quantity assumes, successively, two different values

[SOURCE: IEV 311-07-03, modified]

$$D = G - G_r$$

where

G the indicated value under the effect; and

G_r the indicated value under reference conditions.

Note 1 to entry: The original term in IEV 311-07-03 reads “variation (due to an influence quantity)”. In order not to mix up variation (of the indicated value) and variation of the response, in this standard, the term is called “deviation”.

Note 2 to entry: The deviation can be positive or negative resulting in an increase or a decrease of the indicated value, respectively.

3.9
dosemeter
radiation meter designed to measure the quantities absorbed dose or dose equivalent

Note 1 to entry: In a wider sense, this term is used for meters designed to measure other quantities related to radiation such as exposure, fluence, etc. Such use is deprecated.

Note 2 to entry: This apparatus may require a separate reader to read out the absorbed dose or dose equivalent.

[SOURCE: IEV 394-02-11]

Note 3 to entry: A dosemeter usually consists of a detector and a badge, for example TLD badge with filters.

3.10
dosimetry system
dosemeter, reader and all associated equipment and procedures used for assessing the indicated value

[SOURCE: IEV 394-11-06, modified]

3.11
expanded uncertainty
U
quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand

[SOURCE: GUM 2.3.5]

Note 1 to entry: The expanded uncertainty is obtained by multiplying the combined standard uncertainty by a coverage factor.

Note 2 to entry: A confidence level of 95 % is recommended for the use of this standard.

3.12
indicated value
G
value of the measurand given directly by a measuring instrument on the basis of its calibration curve

[SOURCE: IEV 311-01-08]

Note 1 to entry: In this standard, the indicated value is the one given by the dosimetry systems as the final result of the evaluation algorithm (for example, display of the software, print out) in units of dose equivalent (Sv), see 8.2.

Note 2 to entry: The indicated value is equivalent to the evaluated value in ISO 12794, Annex D.

Note 3 to entry: For details, see Annex B of this standard.

3.13
influence quantity
quantity that is not the measurand but that affects the result of the measurement

Note 1 to entry: For example, temperature of a micrometer used to measure length.

[SOURCE: IEV 394-20-27; GUM B.2.10]

Note 2 to entry: If the effect on the result of a measurement of an influence quantity depends on another influence quantity, these influence quantities are treated as a single one. In this standard, this is the case for two pairs of influence quantities:

1 – radiation energy and angle of incidence,

2 – ambient temperature and relative humidity.

3.14
influence quantity of type F
influence quantity whose effect on the indicated value is a change in response

Note 1 to entry: An example is radiation energy and angle of radiation incidence.

Note 2 to entry: F stands for factor. The indication due to radiation is multiplied by a factor due to the influence quantity.

3.15
influence quantity of type S
influence quantity whose effect on the indicated value is a deviation independent of the indicated value

Note 1 to entry: An example is the electromagnetic disturbance.

Note 2 to entry: All requirements for influence quantities of type S are given with respect to the value of the deviation D.

Note 3 to entry: S stands for sum. The indication is the sum of the indication due to radiation and due to the disturbance.

3.16
lower limit of the measuring range
H_{low}
lowest dose value included in the measuring range

3.17
maximum rated measurement time
t_{max}
longest continuous period of time over which the dose is accumulated and over which all requirements of this standard are fulfilled

Note 1 to entry: The maximum rated measuring time depends on the lower limit of the measuring range H_{low}, the fading, and other influences.

Note 2 to entry: The beginning of this period of time can for example be erasing the dose by heating (at TLDs) or a dose reset by means of software (at DIS).

3.18
measured value
M
value that can be obtained from the indicated value G by applying the model function for the measurement

Note 1 to entry: The uncertainty model function combines the indicated value G with the reference calibration factor N_0, the correction for non-linearity r_n, the l deviations D_p (p = 1..l) for the influence quantities of type S, and the m relative response values r_q (q = 1..m) for the influence quantities of type F:

$$M = \frac{N_0}{r_n \prod_{q=1}^{m} r_q} \left[G - \sum_{p=1}^{l} D_p \right].$$

This uncertainty model function is necessary to evaluate the uncertainty of the measured value according to the GUM (see GUM, 3.1.6, 3.4.1 and 4.1).

Note 2 to entry: For "model" function, see Note 2 to 3.35.

Note 3 to entry: The calculations according to this model function are usually not performed, only in the case that specific influence quantities are well known and an appropriate correction is applied.

Note 4 to entry: If necessary, another model function closer to the design of a certain dosimetry system may be used.

Note 5 to entry: For details, see Annex B.

3.19
measuring range
range defined by two values of the measurand, or quantity to be supplied, within which the limits of uncertainty of the measuring instrument are specified

[SOURCE: IEV 311-03-12]

Note 1 to entry: In this standard, the measuring range is the range of dose equivalent, in which the requirements of this standard are fulfilled and thus the uncertainty is limited.

3.20
mandatory range (of use)
smallest range being specified for an influence quantity or instrument parameter over which the dosimetry system shall operate in compliance with this standard

Note 1 to entry: The mandatory ranges of the influence quantities dealt with in this standard are given in the second column of Tables 3 to 7.

3.21
personal dose equivalent
$H_p(d)$
dose equivalent in soft tissue, at an appropriate depth, d, below a specified point on the body

[SOURCE: ICRU 51]

Note 1 to entry: The recommended depths are 10 mm for penetrating radiation and 0,07 mm for superficial radiation. [IEV 393-14-97]

Note 2 to entry: Soft tissue means ICRU 4-element tissue, see ICRU Report 39.

3.22
point of test
point in the radiation field at which the conventional true value of the quantity to be measured is known

[SOURCE: ISO 4037-3, Definition 3.2.6, modified]

3.23
preparation
normal treatment of dosemeters or detectors before a dose measurement, for example, a procedure to erase stored dose information, reset the dose information by means of software, cleaning, which the dosemeters or detectors are intended to be subjected to in routine use

3.24
rated range (of use)
specified range of values which an influence quantity can assume without causing a deviation or variation of the response exceeding specified limits

[SOURCE: IEV 311-07-05, modified]

Note 1 to entry: In IEV 311-07-05, the term reads “nominal range of use”. In this standard, “rated range” is used in order to avoid complicated terms like “the range of use of an influence quantity” but to have terms that are easily readable like “the rated range of an influence quantity”.

Note 2 to entry: Influence quantities can be either of type S or of type F.

3.25
reader
instrument designed to read out one or more detectors in a dosemeter

[SOURCE: IEV 394-11-10, modified]

Note 1 to entry: Signal of a passive dosimeter can be amount of light, amount of charge, transparency of film and so on. Each type of passive dosimeter thus has very a different type of reader.

Note 2 to entry: In IEV, the term reads “dosemeter reader”.

3.26
readout
process of measuring the stored dose information of a detector in a reader

3.27
reference conditions
set of specified values and/or ranges of values of influence quantities under which the uncertainties admissible for a dosimetry system are the smallest

[SOURCE: IEV 311-06-02, modified]

3.28
reference direction
direction, in the coordinate system of a dosemeter, with respect to which the angle to the direction of radiation incidence is measured in unidirectional fields

[SOURCE: ISO 4037-3, 3.2.7]

3.29
reference orientation
(dosemeter) orientation for which the direction of the incident radiation coincides with the reference direction of the dosemeter

[SOURCE: ISO 4037-3, 3.2.8]

3.30
reference point of a dosemeter
physical mark or marks on the outside of the dosemeter to be used in order to position it with respect to the point of test

[SOURCE: IEV 394-20-15, modified]

3.31
reference response
R_0
response for a reference value $C_{r,0}$ of the quantity to be measured under reference conditions

$$R_0 = \frac{G_{r,0}}{C_{r,0}}$$

where $G_{r,0}$ is the corresponding indicated value

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 are given in Table 2.