

Radiation protection instrumentation — Installed dose ratemeters, warning assemblies and monitors — X and gamma radiation of energy between 50 keV and 7 MeV

ICS 17.240

National foreword

This British Standard reproduces verbatim IEC 60532:1992 and implements it as the UK national standard. It supersedes BS 5566:1978 which is withdrawn. The UK participation in its preparation was entrusted to Technical Committee NCE/2, Health physics instrumentation, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

From 1 January 1997, all IEC publications have the number 60000 added to the old number. For instance, IEC 27-1 has been renumbered as IEC 60027-1. For a period of time during the change over from one numbering system to the other, publications may contain identifiers from both systems.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

This British Standard, having been prepared under the direction of the Engineering Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 September 2001

Summary of pages

This document comprises a front cover, an inside front cover, the IEC title page, pages 2 to 38, an inside back cover and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

© BSI 08-2001

ISBN 0 580 37358 4

**NORME
INTERNATIONALE
INTERNATIONAL
STANDARD**

**CEI
IEC
532**

Deuxième édition
Second edition
1992-08

**Instrumentation pour la radioprotection –
Débitmètres à poste fixe, ensembles d’alarmes
et moniteurs – Rayonnements X et gamma
d’énergie comprise entre 50 keV et 7 MeV**

**Radiation protection instrumentation –
Installed dose ratemeters, warning assemblies
and monitors – X and gamma radiation of
energy between 50 keV and 7 MeV**



Numéro de référence
Reference number
CEI/IEC 532: 1992

AVA Documents
Document Sharing Hub

CONTENTS

FOREWORD	Page 4
SECTION 1: GENERAL	
Clause	
1.1 Scope and object.....	5
1.2 Normative references	6
1.3 Degrees of requirements	7
1.4 Terminology quantities and units	7
1.5 Qualification tests	10
SECTION 2: DESIGN REQUIREMENTS	
2.1 Construction and performance	10
2.2 Indication facilities	12
2.3 Alarm facilities	13
2.4 Interrelationship between response time and statistical fluctuations	14
2.5 Classification	14
SECTION 3: TEST PROCEDURES	
3.1 Basic tests	14
3.2 Point of test	15
3.3 Background radiation	15
3.4 Statistical fluctuations	15
3.5 Reference gamma radiation	16
3.6 Relative intrinsic error	16
3.7 Variation of response with radiation energy	18
3.8 Variation of response with angle of incidence	19
3.9 Response to beta radiation	21
3.10 Response to neutron radiation (neutron rejection)	22
3.11 Overload characteristics	23
3.12 Statistical fluctuations	23
3.13 Response time	24
3.14 Zero drift	25
3.15 Alarm trip range	26
3.16 Equipment failure alarms	26
3.17 Alarm response time and stability	26
3.18 Warm-up	27
3.19 Power supply	27
3.20 Environmental test requirements	29
3.21 Atmospheric pressure	30
3.22 Sealing	30
3.23 External electromagnetic fields	30
3.24 External magnetic fields	31

Clause	Page
SECTION 4: DOCUMENTATION	
4.1 Type test report	31
4.2 Certificate	31
4.3 Operation and maintenance manual	32
TABLES	33
FIGURE 1	37
ANNEX A	38

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RADIATION PROTECTION INSTRUMENTATION –
INSTALLED DOSE RATEMETERS, WARNING ASSEMBLIES
AND MONITORS – X AND GAMMA RADIATION
OF ENERGY BETWEEN 50 keV AND 7 MeV**

FOREWORD

- 1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.
- 2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.
- 3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

This International Standard has been prepared by Sub-Committee 45B: Radiation protection instrumentation, of IEC Technical Committee No. 45: Nuclear instrumentation.

This second edition replaces the first edition of 1976.

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

DIS	Report on Voting	Amendment to DIS	Report on Voting
45B(CO)84	45B(CO)101	45B(CO)104	45B(CO)112

Full information on the voting for the approval of this standard can be found in the Voting Reports indicated in the above table.

Annex A is for information only.

RADIATION PROTECTION INSTRUMENTATION – INSTALLED DOSE RATEMETERS, WARNING ASSEMBLIES AND MONITORS – X AND GAMMA RADIATION OF ENERGY BETWEEN 50 keV AND 7 MeV

SECTION 1: GENERAL

1.1 Scope and object

1.1.1 This International Standard applies to installed dose ratemeters, warning assemblies and monitors, as defined in clause 1.4.

It covers equipment intended to measure air kerma, ambient dose equivalent, or other isotropic dose or exposure quantities due to X or gamma radiation of energy between 50 keV and 7 MeV for the purposes of radiation protection. Instruments measuring over a more limited energy range fall within the scope of this standard provided they cover at least the range of 80 keV to 1,5 MeV.

NOTE - 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 to provide alarms when the radiation field goes outside predetermined limits. Typically, the range of measurement will be from the order of 10 μGy (or μSv) per hour upwards. This standard may not be directly applicable to equipment for use in pulsed radiation fields, for example those emanating from pulsed radiation or particle accelerators.

National regulations or practice may require the measurement of air kerma, ambient dose equivalent or some other dose or exposure quantity.

This standard may be applied to the performance characteristics of equipment to measure any such quantity. For example, the numerical values given for the requirements for the radiation characteristics apply to any case but the conventionally true values would be expressed in the appropriate quantity.

1.1.2 The assemblies considered in this standard comprise at least:

- a detector sub-assembly (e.g. ionization chamber, Geiger-Müller counter tube, etc.);
- a measuring sub-assembly, which may be fitted into a centralized panel, which in the case of warning assemblies and monitors provide signal outputs and contacts capable of activating alarm or other trip circuits for the purpose of radiation protection.

1.1.3 This standard is also applicable to installed dose rate measuring assemblies designed for special application (e.g. very high dose rates). However, some of the requirements may need to be amended or supplemented according to the particular characteristics of such assemblies.

1.1.4 This standard is not applicable to criticality monitors or to assemblies intended to give information about operational parameters of nuclear plants for control purposes.

1.1.5 Assemblies designed to perform combined functions shall comply with the requirements pertaining to each of these functions. Assemblies intended for, and designed to perform, only one function, but which are also capable of executing other functions, need only comply with the requirements for their intended function, but compliance with the requirements for the other functions is desirable.

1.1.6 This standard is not applicable to the operating characteristics of indicating or recording instruments as such (e.g. indicating meters, recorders, alarms, etc.).

The characteristics of such instruments shall be in conformity with the general requirements appropriate to them.

1.1.7 This publication specifies standard general characteristics, general test procedures, radiation, electrical, safety and environmental characteristics and the identification certificate for assemblies defined in the scope.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 50(151): 1978, *International Electrotechnical Vocabulary (IEV) – Chapter 151: Electrical and magnetic devices*.

IEC 68, *Environmental testing*.

IEC 278: 1968, *Documentation to be supplied with electronic measuring apparatus*.

IEC 293: 1968, *Supply voltages for transistorized nuclear instruments*.

ISO 4037: 1979, *X and gamma reference radiations for calibrating dosimeters and dose ratemeters and for determining their response as a function of photon energy*.

ISO 6980: 1984, *Reference beta radiations for calibrating dosimeters and dose rate-meters and for determining their response as a function of beta radiation energy*.

ICRU 33: 1980, *Radiation quantities and units*.

ICRU 39: 1985, *Determination of dose equivalents resulting from external radiation sources*.

ICRU 43: 1988, *Determination of dose equivalents from external radiation sources – Part 2*.

1.3 Degrees of requirements

In this standard, requirements are defined as follows:

- the word "shall" signifies a mandatory requirement; (where appropriate a qualifying statement is included to indicate that there may be an allowable exception);
- the word "may" signifies an acceptable method, or an example of good practice.

1.4 Terminology quantities and units

1.4.1 *Ambient dose equivalent*

The ambient dose equivalent $H^*(10)$, is the dose equivalent that would be produced by the corresponding aligned and expanded field at a depth of 10 mm in the International Commission on Radiation Units and Measurements (ICRU) sphere on the radius opposing the direction of the aligned field. For further details, refer to ICRU 39.

The name of the unit of measurement is the sievert, Sv ($\text{J} \cdot \text{kg}^{-1}$).

1.4.2 *Air kerma*

The air kerma is the quotient of dE (the sum of the initial kinetic energies of all the charged particles liberated by uncharged ionizing particles in a given mass of air) by dm (that mass). i.e.

$$K = \frac{dE}{dm}$$

The name of the unit of measurement is the gray, Gy ($\text{J} \cdot \text{kg}^{-1}$). For further details refer to ICRU 33.

1.4.3 *Dose*

In this standard, the quantity to be measured, whether air kerma, ambient dose equivalent, or some other dose or exposure quantity, is generally referred to simply as "dose". Only where it is necessary to differentiate between the quantities is the word dose further qualified.

1.4.4 *Dose ratemeter*

A radiation meter intended to measure the dose rate due to X or gamma radiation and including one or several radiation detectors and associated sub-assemblies or basic function units.

1.4.5 *Dose rate warning assembly*

An assembly intended to give a visual and/or audible warning that the dose rate due to X or gamma radiation exceeds a certain predetermined value or that the measured value is not within certain predetermined limits.

1.4.6 *Dose rate monitor*

An assembly having the functions of both a dose ratemeter and a dose rate warning assembly.

1.4.7 *Conventionally true dose rate*

The best estimate of the true dose rate used for calibration of equipment; this value and its uncertainty shall be determined from a secondary or a primary standard, or by a reference instrument which has been calibrated against a secondary or primary standard.

1.4.8 *Indicated dose rate*

The dose rate indicated by the measuring assembly under test.

1.4.9 *Coefficient of variation, V*

The ratio of the estimate of the standard deviation, s , to the arithmetic mean $\bar{x}$ of a set of n measurements x_i , given by the following formula:

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

1.4.10 *Reference point of assembly*

The reference point of an assembly is defined by a physical mark or marks on the assembly which are used to position it at a point where the conventionally true value of the quantity to be measured is known.

1.4.11 *Point of test*

The point of test is the point at which the reference point of the assembly is placed and at which the conventionally true values of air kerma rate are known. For all tests involving the use of radiation the reference point of the assembly shall be placed at the point of test, and apart from the test for variation in response with angle of incidence, in the orientation indicated by the manufacturer, i.e. with the radiation field incident from the manufacturer's stated calibration direction.

1.4.12 *Error of indication*

The difference between the indicated dose rate and the conventionally true dose rate at the point of measurement.

1.4.13 *Relative error of indication*

The quotient, expressed as a percentage, of the error of indication by the conventionally true dose rate.

The relative error of indication I , expressed as a percentage, is given by the relation:

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

where

$\dot{D}_i$ is the indicated dose rate

$\dot{D}_t$ is the conventionally true dose rate

1.4.14 *Relative intrinsic error*

The relative error of indication of an assembly with respect to a specified dose rate under specified reference conditions.

1.4.15 *Effective range of measurement*

The range of measurement within which the requirements of this standard are met.

1.4.16 *Response time*

The time delay between initial exposure of the detection assembly to a given dose rate and the attainment of 90 % of the equilibrium reading or, for integrating monitors, 90 % of the equilibrium value of the first derivative of the indication, with respect to time.

1.4.17 *Units*

This standard uses the SI system of units*. The following units of practical importance will also be used where appropriate:

- for time: years, days, hours, minutes;
- for energy: electron-volt.

1.4.18 *Reference response*

The reference response R_{ref} is the response of the assembly under standard test conditions (table 1) to unit reference dose rate and is expressed by the relation:

$$R_{\text{ref}} = \frac{I_{\text{rs}} - I_{\text{b}}}{\dot{D}_{\text{rs}}}$$

where

I_{rs} is the indication due to reference dose rate

I_{b} is the indication due to radiation background

$\dot{D}_{\text{rs}}$ is the reference dose rate

1.4.19 *Manufacturer and purchaser*

The term "manufacturer" includes the designer of the equipment. The term "purchaser" includes the user of the equipment.

* International Bureau of Weights and Measures: International System of Units (SI), third edition (1977).

1.5 Qualification tests

Qualification tests are performed in order to verify that the requirements of a specification are fulfilled.

Qualification tests are subdivided into type tests and routine tests.

1.5.1 *Type test*

A test of one or more devices made to a certain design to show that the design meets certain specifications. [IEV 151-04-15]

1.5.2 *Routine test*

A test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria. [IEV 151-04-16]

1.5.3 *Acceptance test*

A contractual test to prove to the customer that the device meets certain conditions of its specification. [IEV 151-04-20]

SECTION 2: DESIGN REQUIREMENTS

2.1 Construction and performance

2.1.1 Equipment may be designed as a single assembly with the detector adjacent to or contained within the assembly, or with the detector remote from the remaining equipment.

In the latter case the detector may be up to 10 m from any electronics (head amplifier) and the detector and any head amplifier up to 100 m or more from the indicator and alarm sub-assembly.

It may be desirable for all these options to be provided by a single basic design of equipment.

It would also be desirable for the design to provide for the use of alternative types of detectors with essentially the same indication and alarm sub-assembly.

2.1.2 The equipment shall measure the dose rate due to X or gamma rays over an energy range of at least 80 keV to 1,5 MeV. Effective response to lower energies down to 50 keV and higher energies up to 7 MeV may be specified. The range of the equipment shall be at least three full decades of dose rate; five or more decades may be required in many applications. Manual range switching shall be avoided.

The design of the equipment shall take account of the practical use of assemblies, noting that they may be required to measure radiation fields incident from various angles relative to their location. (Typically wall or structural steelwork mounting is involved with radiation originating from distributed sources. The requirement is sometimes best considered a

'front on' (2π) challenge or, on other occasions, a 'side on' challenge requiring a better approach to 4π geometry, but little requirement for 'end on' response.)

2.1.3 Assemblies shall be designed so as to limit as far as possible any undesirable response to electromagnetic and ionizing radiations other than X or gamma radiation.

2.1.4 Where detectors are to be used in high neutron radiation fields, the detector sub-assembly should be constructed of materials which will minimize the effects of neutron activation.

2.1.5 Information regarding the reference point of the detector for calibration purposes shall be indicated on the outer surface. The orientation of the instrument relative to the reference calibration direction shall be given in relation to the instrument enclosure.

The manufacturer shall also explain the assumptions he has made with respect to the use of the assembly in relation to location relative to radiation sources and structures and how these have affected his choice of calibration direction and the optimization of the design in respect to angular response.

2.1.6 Controls and adjustments which affect calibration and alarm settings shall be so designed that access to them can be limited to authorized persons.

2.1.7 Provisions shall be made to permit testing of lamps or other visual warning indicators.

2.1.8 Provision shall normally be made to allow introduction of a signal input simulating the detector output and, where possible, this shall not require access to the head unit. These are in addition to the alarm check facilities and may simply be arrangements for the injection of a suitable test signal. Full details shall be provided of any special test equipment required.

2.1.9 If a desiccant is used it shall be arranged so that when spent a colour change can be seen through a transparent window from the exterior of the monitor.

2.1.10 The detector sub-assembly shall be constructed in such a manner as to facilitate decontamination.

2.1.11 The monitor shall be designed for a mean time between failure (MTBF) for "certain" failures (failures raising an alarm or otherwise indicated) of 10 000 h and for "uncertain" failures (failures not indicated) of 50 000 h. Evidence shall be provided by the manufacturer to justify this performance. This will normally be in the form of theoretical assessment and, in this case, the source data and assessment method shall be agreed between manufacturer and purchaser. It would also be desirable for the theoretical assessment to be reviewed against subsequent operational experience.

2.1.12 In some circumstances equipment may be required to operate in locations subject to seismic disturbances. Any requirements for the equipment to operate in such conditions