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Radiation protection instrumentation – Electronic counting dosemeters for pulsed fields of ionizing radiation

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

RADIATION PROTECTION INSTRUMENTATION –
ELECTRONIC COUNTING DOSEMETERS
FOR PULSED FIELDS OF IONIZING RADIATION

FOREWORD

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 62743, which is a technical specification, has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
45B/706/DTS	45B/726A/RVC

Full information on the voting for the approval of this technical specification 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

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

The specification and determination of the special characteristics required for dosemeters to be used in pulsed fields of ionizing radiation have been excluded from all standards for direct reading personal and environmental dosemeters issued before 2012 for radiation protection purposes. These standards only specify characteristics for continuous radiation. This Technical Specification provides the necessary information for the measurement of one single radiation pulse, which is the most difficult situation to be measured. The characteristics of a dosemeter for repeated pulses is expected to be better than for one single radiation pulse with the same parameters but worse than for continuous radiation, i.e., in between of the characteristics for these two extreme conditions. This Technical Specification applies for such direct reading dosemeters that use pulse counting for the determination of the measured dose value. Dosemeters that use delayed pulses, e.g., due to activation by neutrons, are excluded.

The concept is similar to the concept used for other influence quantities, e.g., radiation energy. The workplace is characterized by the parameter range occurring at that workplace, i.e., in the case of energy the expected possible values of radiation energy. It can then be determined if the dosemeter under consideration can be used. The required parameters for a workplace where pulsed radiation occurs are

– the minimum value of the radiation pulse duration, $t_{\text{pulse, min}}$, occurring at the workplace,
– the maximum value of the dose rate during the radiation pulse, $\dot{H}_{\text{pulse,max}}$, occurring at the workplace,
– the maximum value of the dose per radiation pulse, $H_{\text{pulse, max}}$, occurring at the workplace.

The parameters to be determined by the type test of the counting dosemeter are

– the maximum value of the measurable dose rate in the pulse, $\dot{H}_{\text{count,max}}$,

– the dead time of the detector, t_{dead},
– the dose indication per each counting event which is registered by the dosemeter electronics, G_{count},
– the type of the dead time, i.e., extendable or non-extendable dead time, and finally
– the measurement cycle time of the dosemeter, T_{cycle}.

In principle, the parameters resulting from the type test could be determined using continuous radiation fields if the detector is connected to a simple, linear and straight forward counting electronics. But nearly any counting dosemeter exhibits one or more of the following properties. It

– uses internal range switching,
– uses software to correct for known deficiencies, e.g., the dead time or the radiation energy,
– uses special, proprietary algorithms,
– adjusts the measurement cycle time, T_{cycle}, to the dose rate, $\dot{G}_{\text{dose}}$, measured by the dosemeter,
– mitigates the effect of EMC-pulses and mechanical drops.

All these properties could affect the results when determining the characteristics for pulsed radiation fields by using continuous radiation fields. The conclusion is that measurements using pulsed radiation fields are required for testing of dosemeters.

As a help to the user to judge whether or not the dosemeter under consideration can be used, Table A.1 in the informative Annex A gives some parameter values for typical workplaces where pulsed radiation occurs. They are based on the knowledge available in 2012 and may change with the next generation of pulsed radiation generating equipment.

This Technical Specification contains much information for which worldwide experience is not available at the date of its development. Therefore, it was decided to publish it as a Technical Specification. It is expected that within the next years this experience will be gained and then maintenance of this publication could lead to an International Standard.

RADIATION PROTECTION INSTRUMENTATION – ELECTRONIC COUNTING DOSEMETERS FOR PULSED FIELDS OF IONIZING RADIATION

1 Scope

This Technical Specification applies to all types of counting dosemeters, irrespective of the measuring quantity and the type of radiation intended to be measured. It ensures that a single radiation pulse can be correctly measured even if the dosemeter is in the internal state relevant for measuring background or environmental radiation. The characteristics of the dosemeter for repeated pulses is expected to be better than for one single radiation pulse with the same parameters but worse than for continuous radiation, i.e., in between of the characteristics for these two extreme conditions. This Technical Specification does not specify the characteristics of the dosemeter for repeated pulses. The Technical Specification does not apply for those types of counting dosemeters that either

– do not have an indication or software read-out of the dose rate and the number of pulses counted,

– convert the non-pulsed detector signal to counts by a converter, or

– use nuclear reactions to generate long and nearly continuous secondary radiation fields which then are measured by the dosemeter using counting techniques instead of measuring the direct radiation pulse.

The pulsed radiation source is characterized by the parameters

– radiation pulse duration, t_{pulse},

– pulse peak dose rate, $\dot{H}_{\text{pulse,peak}}$,

– dose per radiation pulse, H_{pulse}.

This Technical Specification considers the pulsation of the radiation field as an additional influence quantity like particle energy and direction of radiation incidence. Therefore, the tests described are additional to all the tests in the respective standards.

This technical specification describes methods to determine the characteristic parameters of the counting dosemeter. A prerequisite of the method is that the model function of the dosemeter can sufficiently be approximated by

$$G_{\text{dose}} = G_{\text{count}} \times n_{\text{count}} \times k_{\text{dead}} \tag{1}$$

where
- G_{dose} is the dose indication of the dosemeter,
- G_{count} is the dose indication per counting event,
- n_{count} is the number of counting events counted by the dosemeter, and
- k_{dead} is the correction for dead time losses.

This simplified model function should not fully describe the dosemeter but it should be valid only – maybe with effective values – for the tests in the case of a single pulse occurring when the dosemeter is in the internal state relevant for measuring background or environmental radiation, i.e., the dosemeter has not performed any specific parameter adjustment for high dose rate. In this sense this simplified model function uses effective parameters specific for pulsed radiation.

This technical specification is applicable to all types of radiation for which a suitable pulsed reference field is available and all other requirements are fulfilled.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at http://www.electropedia.org)

ISO 4037-3:1999, *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*

The International System of Units, 8th edition, International Bureau of Weights and Measures, 2006.

3 Terms and definitions, abbreviations and symbols, quantities and units

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-395[1] and the following apply.

3.1.1
continuous radiation
<area and individual dosimetry> ionizing radiation with a constant dose rate at a given point in space for time intervals longer than 10 s, if the power-on and -off processes are neglected

Note 1 to entry: The time span of 10 s is taken from type test requirements of IEC 61526:2010 and IEC 60846-1:2009 that the dosemeter shall be capable of detecting changes in the dose rate within 10 s.

3.1.2
counting event
ionizing interaction by which one count is produced by the dosemeter electronics

Note 1 to entry: Adapted from IEC 60050-531:1974, 531-13-01.

3.1.3
dead time correction
correction to be applied to the observed number of counting events in order to take into account the number of counting events lost due to the dead time

Note 1 to entry: Adapted from IEC 60050-394:2007, 394-39-22.

3.1.4
dead time
t_{dead}
time interval after the initiation of a counting event caused by an ionizing event, during which a dosemeter operating in pulse mode cannot respond to a further ionizing event

Note 1 to entry: Adapted from IEC 60050-394:2007, 394-38-50.

[1] To be published. IEC 60050-395 will replace and cancel IEC 60050-393 and IEC 60050-394.

3.1.5
dose of a radiation pulse
H_{pulse}
dose value attributed to one radiation pulse

3.1.6
dose indication
G_{dose}
indication of the counting dosemeter in terms of dose

3.1.7
dose indication per counting event
G_{count}
indication increment of the counting dosemeter for one counting event

3.1.8
dose rate indication
$\dot{G}_{dose}$
indication of the counting dosemeter in terms of dose rate

3.1.9
extendable dead time
paralyzable dead time
dead time that is extended if further ionizing events occur during the dead time interval

3.1.10
internal state
soft and hardware parameters set internally (by the dosemeter)

EXAMPLE When the dosemeter is for a long time span not exposed to any artificial radiation then the sensitivity and the cycle time are set to the maximum values to indicate the dose value with the highest resolution possible and to reduce the coefficient of variation of the indication.

3.1.11
ionizing event
any interaction by which one or more ions are produced

[SOURCE: IEC 60050-531:1974, 531-13-01]

3.1.12
maximum measurable dose rate in the pulse
$\dot{H}_{count, max}$
maximum value of the radiation pulse peak dose rate which can be measured by the counting dosemeter without exceeding stated maximum errors

3.1.13
maximum pulse dose
$H_{pulse,max}$
maximum value of the dose of a radiation pulse occurring at a given workplace

3.1.14
maximum pulse peak dose rate
$\dot{H}_{pulse, max}$
maximum value of the pulse peak dose rate occurring at a given workplace