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TECHNICAL SPECIFICATION

Radiation protection instrumentation – Dosemeters for pulsed fields of ionizing radiation

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colour inside

Radiation protection instrumentation – Dosemeters for pulsed fields of ionizing radiation

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

RADIATION PROTECTION INSTRUMENTATION – 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 63050, 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:

Draft TS	Report on voting
45B/903/DTS	45B/925A/RVDTS

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 document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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

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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 2015 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.

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

The instrument parameters to be determined during type test of the dosemeter are:

– the maximum measurable dose rate in the pulse, $\dot{H}_{\text{meas,max}}$,
– the maximum measurable dose in the pulse, $H_{\text{meas,max}}$,
– the minimal pulse duration, $t_{\text{meas,min}}$, and
– the range for the pulse repetition frequency, $f_{\text{meas,min}}$ to $f_{\text{meas,max}}$.

NOTE These parameters may be inter-related depending on the detector used.

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

– has a finite dead time,
– 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 2019 and may change with the next generation of pulsed radiation generating equipment.

This Technical Specification is a generalized version of IEC TS 62743 and not limited to dosemeters using pulse counting techniques. This Technical Specification might replace IEC TS 62743 in the future. 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 – DOSEMETERS FOR PULSED FIELDS OF IONIZING RADIATION

1 Scope

This document applies to all types of dosemeters, irrespective of the type of radiation intended to be measured. Tests according to this document determine whether a single radiation pulse can be measured correctly 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.

The pulsed radiation source is characterized by the parameters:

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

Annex A gives some parameter values for typical workplaces where pulsed radiation occurs.

This document 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 instrument specific standards.

This document describes methods to determine the following characteristic parameters of the dosemeters:

– the maximum measurable dose rate in the pulse, $\dot{H}_{\text{meas,max}}$,
– the maximum measurable dose in the pulse, $H_{\text{meas,max}}$,
– the minimal pulse duration, $t_{\text{meas,min}}$, and
– the range for the pulse repetition frequency, $f_{\text{meas,min}}$ to $f_{\text{meas,max}}$.

NOTE These parameters may be inter-related depending on the detector used.

It is applicable to photon radiation but basically can be adapted to all types of radiation for which a suitable pulsed reference field is available. The term dose is used in this document in the sense of dose equivalent, but the requirements can also be adapted to air kerma, exposure or other quantities expressing the amount of radiation.

The parameter pulse repetition frequency, f_{pulse}, is included in the testing procedures, but for this inclusion additional work has to be done. Especially, reference fields for radiation conditions in surrounding fields of accelerators are missing (high pulse repetition frequency, ultra-short pulses).

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

IEC 61267:2005, *Medical diagnostic X-ray equipment – Radiation conditions for use in the determination of characteristics*

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 TS 18090-1:2015, *Radiological protection – Characteristics of reference pulsed radiation – Part 1: Photon radiation*

3 Terms and definitions, abbreviated terms 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, ISO TS 18090-1 and the following 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

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

[SOURCE: ISO TS 18090-1:2015, 3.2]

3.1.2
dose equivalent per radiation pulse
H_{pulse}
dose equivalent value of one radiation pulse at a point in the radiation field

[SOURCE: ISO TS 18090-1:2015, 3.3 modified: The term “photon radiation field” has been replaced by “radiation field”.]

3.1.3
dose indication
G_{dose}
indication of the dosemeter in terms of dose

3.1.4
dose rate indication
$\dot{G}_{\mathrm{dose}}$
indication of the dosemeter in terms of dose rate

3.1.5
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.

3.1.6
maximum measurable dose in the radiation pulse
$H_{\mathrm{meas,\,max}}$
maximum value of one radiation pulse dose which can be measured by the dosemeter without exceeding stated maximum errors

3.1.7
maximum measurable dose rate in the radiation pulse
$\dot{H}_{\mathrm{meas,\,max}}$
maximum value of one radiation pulse dose rate which can be measured by the dosemeter without exceeding stated maximum errors

3.1.8
maximum radiation pulse dose
$H_{\mathrm{pulse,max}}$
maximum dose of one radiation pulse occurring at a point in the radiation field

3.1.9
maximum radiation pulse dose rate
$\dot{H}_{\mathrm{pulse,\,max}}$
maximum radiation pulse dose rate occurring at a point in the radiation field

3.1.10
measurement cycle time
T_{cycle}
time interval required by the counting dosemeter for one sequence of the repeated operations to determine the actual value of the indication

3.1.11
pulsed radiation
<area and individual dosimetry> ionizing radiation which never has a constant dose rate at a given point in space for time intervals longer than 10 s

[SOURCE: ISO TS 18090-1:2015, 3.9]

3.1.12
radiation pulse
abrupt variation of short duration of the radiation dose rate from zero followed by a rapid return to zero

[SOURCE: IEC 60050-702:1992, 702-03-01, modified: The term “pulse” has been replaced by “radiation pulse” and the words “a physical quantity” and “the initial value” have been replaced by “the radiation dose rate from zero” and “zero”.]

3.1.13
radiation pulse duration
radiation pulse width
t_{pulse}
interval of time between the first and last instants at which the instantaneous air kerma rate value of the equivalent trapezoidal pulse reaches 50 % of its maximum value

[SOURCE: ISO TS 18090-1:2015, 3.11]

3.1.14
radiation pulse dose equivalent rate
pulse dose equivalent rate
$\dot{H}_{\text{pulse}}$
quotient of the dose equivalent per radiation pulse and the radiation pulse duration at a point in the radiation field

Note 1 to entry: The dose equivalent per radiation pulse can be measured either by an integral measurement with an ionisation chamber or time resolved by a suitable instrument, both calibrated in terms of the relevant quantity.

[SOURCE: ISO TS 18090-1:2015, 3.14 modified: The symbol $\dot{H}_{\text{a,pulse}}$ has been changed to $\dot{H}_{\text{pulse}}$.]

3.1.15
pulse repetition frequency
f_{pulse}
number of pulses in a periodic pulse train divided by the duration of the train

[SOURCE: IEC 60050-702:1992, 702-03-07]

3.1.16
pulse train
discrete sequence of a finite number of pulses

Note 1 to entry: The sequence can be periodic or non-periodic.

[SOURCE: ISO TS 18090-1, 3.8]

3.2 Abbreviated terms and symbols

Table 1 gives a list of the symbols and abbreviated terms used.

Table 1 – Abbreviated terms and symbols

Symbol	Meaning	Unit
G_{dose}	Dose indication of the dosemeter	Sv
$G_{\text{dose, i}}$	Dose indication of the dosemeter for the pulse condition no. *i*	Sv
$\dot{G}_{\text{dose}}$	Dose rate indication of the dosemeter	Sv h^{-1}
H_0	Lower limit of the measuring range of the dosemeter	Sv
H_{pulse}	Dose per radiation pulse	Sv
$H_{\text{pulse, i}}$	Dose of one radiation pulse for the pulse condition no. *i*	Sv
$H_{\text{pulse, max}}$	Maximum dose of one radiation pulse occurring at a point in the radiation field	Sv
$H_{\text{meas, max}}$	Maximum measurable dose in the pulse	Sv
$\dot{H}_{\text{meas, max}}$	Maximum measurable dose rate in the pulse	Sv h^{-1}
$\dot{H}_{\text{pulse, max}}$	Maximum dose rate of the radiation pulse occurring at a point in the radiation field	Sv h^{-1}
$\dot{H}_{\text{pulse}}$	Pulse dose rate	Sv h^{-1}
$\dot{H}_{\text{pulse}, i}$	Pulse dose rate for the pulse condition no. *i*	Sv h^{-1}
f_{pulse}	Pulse repetition frequency	s^{-1}
$f_{\text{meas,min}}$ $f_{\text{meas,max}}$	Minimal / maximal pulse repetition frequency at which the dosemeter can measure	s^{-1}
t_{pulse}	Radiation pulse duration	s
$t_{\text{pulse,min}}$	Minimal radiation pulse duration	s
$t_{\text{meas,min}}$	Minimal radiation pulse duration at which the dosemeter can measure	s

3.3 Quantities and units

In the present document, units of the International System (SI) are used. The definitions of radiation quantities are given in IEC 60050-395.

Multiples and submultiples of SI units are used, when practicable, according to the SI system.

4 General test procedure

4.1 Nature of test

All tests are considered as type tests. They treat the pulsation of the radiation field as an additional influence parameter like particle energy and direction of radiation incidence. These tests are additional to all the tests in the instrument specific standards.

4.2 Reference conditions and standard test conditions

The general reference conditions and standard test conditions are the same as stated in the instrument specific standard for the type of dosemeter under test. The special reference conditions for tests concerning pulsed radiation are given in Table 2.

5 General requirements

5.1 Summary of requirements

The response of the dosemeter shall not change by more than ± 20 % due to the pulsation of the field as long as the dosemeter is considered to be suitable for the measurement in pulsed radiation fields. In addition, an overload up to a factor of 100, or 1 000 Sv h^{-1} if this is smaller, shall be indicated or, if an indication is not given, shall not reduce the dose indication below the value obtained for the pulse with the maximum dose rate for which the dosemeter is considered to be suitable.

The maximum measurable dose in the pulse, $H_{\text{meas,max}}$, should not be smaller than 1 mSv, as this is the dose limit for a pregnant woman / an unborn child. Other values may apply depending on the local legislation.

The requirements are summarized in Table 3.

NOTE The factor 100 can be found, e.g., in the overload requirements of IEC 60846-1:2009 (8.8.1.2 and 8.8.2.2).

5.2 Parameters required to be known of the pulsed radiation field

The following parameters of the pulsed radiation field at the workplace at which the dosemeter is intended to be used shall be known by the user of the dosemeter in order to verify whether they are covered by the dosemeter's parameters, see 5.3:

– the maximum dose rate during the radiation pulse, $\dot{H}_{\text{pulse,max}}$, occurring at the workplace,

– the maximum dose per radiation pulse, $H_{\text{pulse, max}}$, occurring at the workplace,

– the minimum radiation pulse duration, $t_{\text{pulse, min}}$, occurring at the workplace,

– the range of the pulse repetition frequency, f_{pulse}, occurring at the workplace.

5.3 Parameters required to be determined of the dosemeter

The determination of the following parameters of the dosemeter is described in Clause 6:

– maximum measurable dose rate in a radiation pulse, $\dot{H}_{\text{meas, max}}$,

– the maximum measurable dose in the pulse, $H_{\text{meas,max}}$,

– the minimal pulse duration, $t_{\text{meas,min}}$,

– the range for the pulse repetition frequency, $f_{\text{meas,min}}$ to $f_{\text{meas,max}}$.

NOTE These parameters may be inter-related depending on the detector used.

5.4 Criteria for suitability of a dosemeter in pulsed radiation fields

5.4.1 General

The criteria given below are valid for any type of pulsed radiation field and are derived from the requirement given in 5.1. The criteria depend on the pulse duration of one single radiation pulse, t_{pulse}. 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.

NOTE Some additional work has to be done to include repeated pulses: especially for repeated ultra-short pulses at accelerators a radiation protection reference field. These field are not sufficiently covered by this document.

5.4.2 Requirements

The values occurring at the workplace of:

– the maximum dose rate during the radiation pulse, $\dot{H}_{\text{pulse, max}}$,

– the maximum dose per radiation pulse, $H_{\text{pulse,max}}$,

– the minimum radiation pulse duration, $t_{\text{pulse,min}}$, and

– the range of the pulse repetition frequency, f_{pulse},

shall be within the acceptable performance range of:

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

– the maximum measurable dose in the pulse, $H_{\text{meas,max}}$,

– the minimal pulse duration, $t_{\text{meas,min}}$, and

– the range for the pulse repetition frequency, $f_{\text{meas,min}}$ to $f_{\text{meas,max}}$,

determined for the dosemeter.

5.4.3 Method of test and interpretation of the results

Check if $\dot{H}_{\text{pulse, max}} \leq \dot{H}_{\text{meas, max}}$, $H_{\text{pulse,max}} \leq H_{\text{meas,max}}$, $t_{\text{pulse,min}} \geq t_{\text{meas,min}}$, and $f_{\text{meas,min}} \leq f_{\text{pulse}} \leq f_{\text{meas,max}}$ is fulfilled, see 6.2 for $\dot{H}_{\text{meas,max}}$, $H_{\text{meas,max}}$, $t_{\text{meas,min}}$ and $f_{\text{meas, min}}$, $f_{\text{meas, max}}$.

According to this method of test, the dosemeter is suitable for the considered workplace. Otherwise the dosemeter is not suitable for the workplace considered and shall not be used.

5.5 Mechanical characteristics

Not applicable.

5.6 Requirements for the documentation

The manufacturer shall state the time that the dosemeter requires to come back to its internal state relevant for measuring background or environmental radiation after any additional external radiation field is switched off.

6 Radiation detection requirements

6.1 General

The characteristic parameters of the dosemeter shall be determined using pulsed radiation.

6.2 Maximum measurable dose rate value, $\dot{H}_{\text{meas, max}}$

6.2.1 Requirements

The maximum measurable dose rate value of the dosemeter, $\dot{H}_{\text{meas, max}}$, shall at least be 10 Sv h^{-1}.

6.2.2 Method of test

6.2.2.1 Constant pulse dose rate

The maximum measurable dose rate can be determined by exposing the dosemeter to different radiation pulse conditions but the same radiation quality and calculating the response.

a) Expose the dosemeter to a radiation pulse with a duration t_{pulse} of 10 s or more.

   This is the reference condition: at a pulse duration of 10 s the response $\frac{G_{\text{dose,10 s}}}{H_{\text{pulse,10 s}}}$ is assumed to be close to the response at continuous radiation.

NOTE 1 This 10 s reference was chosen to investigate the dependence on the pulse duration only: independent of the radiation energy, the irradiation geometry, i.e. size of the field, use of a phantom, etc.

b) Expose the dosemeter to radiation pulses with, for example, pulse durations t_{pulse} of 1 s, 300 ms, 10 ms, 1 ms and 0,4 ms.

At short pulse durations the dose may be too small to be displayed by the dosemeter. In this case tests a) and b) have to be repeated at a higher dose rate (which results in an increased dose per radiation pulse).

NOTE 2 This test procedure is intended to determine the usability of the dosemeter in typical X-ray fields. It gives only limited information for the use in very short pulses present at accelerators. The fields at accelerators are not sufficiently covered by this document.

These tests should be performed at two dose rates: at 20 % above the lower limit and at 80 % of the upper limit of the dose rate range stated by the manufacturer for pulsed radiation and repeated at least three times per dose rate. It may be necessary to perform the whole test without an appropriate phantom if the field size is too small to cover the whole phantom at high dose rates.

The lower limit should be the less demanding case – if the dosemeter is capable at this dose rate further tests are reasonable. 20 % above the lower limit and 80 % of the upper limit is chosen because dose linearity tests allow up to +/- 20 % for continuous radiation, so 20 % / 80 % should not be a problem due to dose linearity.

If no or only low dependence on the dose rate is expected (e.g. passive systems like TLD, OSL, etc.), starting at the higher limit is reasonable and the lower limit can be skipped if the dosemeter is capable at the high dose rate.

The maximum measurable dose rate of the dosemeter, $\dot{H}_{\text{meas, max}}$, is the dose rate in case b) where the response $\frac{G_{\text{dose,i}}}{H_{\text{pulse,i}}}$ fulfills the relation $0{,}8 \le \frac{G_{\text{dose,i}}}{H_{\text{pulse,i}}} \Big/ \frac{G_{\text{dose,10 s}}}{H_{\text{pulse,10 s}}} \le 1{,}2$ for all tested pulse durations. If this condition cannot be resolved using the pulse conditions given above, additional conditions shall be tested, e.g. additional dose rates or pulse durations.

The minimal pulse duration $t_{\text{meas,min}}$ is the minimal pulse duration t_{pulse} in case b) where the response $\frac{G_{\text{dose,i}}}{H_{\text{pulse,i}}}$ fulfills the relation $0{,}8 \le \frac{G_{\text{dose,i}}}{H_{\text{pulse,i}}} \Big/ \frac{G_{\text{dose,10 s}}}{H_{\text{pulse,10 s}}} \le 1{,}2$ for all tested pulse dose rates.

NOTE 3 This may lead to testing at ultra-short pulses, e.g. with pulse durations < 0,1 ms, which may be realised by linear accelerators or X-ray flash generators. In these fields the usability of the dosemeter may be determined more by the measurable dose per pulse rather than by the dose rate once the pulse duration becomes shorter than the dosemeter's dead time, the ion collection time, etc.

NOTE 4 Figure B.1 in Annex B provides some examples of test results according to this subclause.

6.2.2.2 Constant pulse dose

As an alternative procedure to determine the maximum measurable dose rate of the dosemeter, $\dot{H}_{\text{meas, max}}$, a set of pulse conditions using a constant dose per radiation pulse of, e.g. H_{pulse} = 1 mSv, can be used. Every condition should vary by the pulse duration, i.e. the pulse dose rate will increase if the pulse duration is decreased. The dose rate where the response $\frac{G_{\text{dose,i}}}{H_{\text{pulse,i}}}$ leaves the interval of $0{,}8 \le \frac{G_{\text{dose,i}}}{H_{\text{pulse,i}}} \Big/ \frac{G_{\text{dose,10 s}}}{H_{\text{pulse,10 s}}} \le 1{,}2$ can be used as starting point for the above mentioned procedure.

The maximum measurable dose in the pulse, $H_{\text{meas,max}}$ can be determined by increasing the pulse dose until the relation $0{,}8 \le \frac{G_{\text{dose,i}}}{H_{\text{pulse,i}}} \Big/ \frac{G_{\text{dose,10 s}}}{H_{\text{pulse,10 s}}} \le 1{,}2$ is no longer fulfilled.

NOTE 1 Figure B.2 in Annex B provides some examples of test results according to this subclause.

NOTE 2 This procedure might be useful to determine the usability of the dosemeter in accelerator produced fields.

6.2.2.3 Repeated pulses: pulse trains

For the determination of the performance of the dosemeter in fields with repeated pulses, the tests mentioned above should be performed using 10 radiation pulses with a repetition frequency of 1 Hz. If this works other repetition frequencies should be checked to determine the possible parameter range, i.e. also non integer frequencies, e.g. 1,3 Hz.

Non-integer frequencies are needed to exclude interplays between the repetition frequency and the measurement cycle time of the dosemeter which corresponds typically to integer frequencies, e.g. 1 Hz.

The pulse train should be shorter than typical measurement cycle times of the dosemeter, i.e. ≤ 10 s.

The range for the pulse repetition frequency $f_{\text{meas,min}}$ to $f_{\text{meas,max}}$ is determined by varying the pulse repetition frequency in the range stated by the manufacturer and calculating the response for each condition: $\frac{G_{\text{dose,i}}}{H_{\text{pulse,i}}}$.

The range for the pulse repetition frequency $f_{\text{meas,min}}$ to $f_{\text{meas,max}}$ is the range where the relation $0{,}8 \le \frac{G_{\text{dose,i}}}{H_{\text{pulse,i}}} \Big/ \frac{G_{\text{dose,10 s}}}{H_{\text{pulse,10 s}}} \le 1{,}2$ is fulfilled.

6.2.2.4 Repeated pulses: permanent repeated pulses

For permanent repeated pulses, i.e. pulse trains with duration longer than 10 s additional tests are necessary. The performance of the dosemeter is expected to be better than for single pulses or short pulse trains.

There might be a correction for the duty cycle of the radiation needed in this case.

6.2.3 Interpretation of the results

If the maximum measurable dose rate value of the dosemeter, $\dot{H}_{\text{meas, max}}$, is at least 1 Sv h^{-1}, then the requirement of 6.2.1 is fulfilled.

6.3 Pulse dose rate overload alarm

6.3.1 General

This test shall only be performed if the dosemeter is provided with a pulse dose rate overload alarm and this alarm is set to $\dot{H}_{\text{meas, max}}$.

6.3.2 Requirements

The alarm shall be actuated in not more than 5 % of the pulses, if the radiation pulse dose rate , $\dot{H}_{\text{pulse}}$, is set to 0,7 × $\dot{H}_{\text{meas, max}}$ (pulse condition 1) and shall be actuated in at least 95 % of the pulses, if the radiation pulse dose rate, $\dot{H}_{\text{pulse}}$, is set to 1,3 × $\dot{H}_{\text{meas, max}}$ (pulse condition 2). The alarm shall not be deactivated automatically.

6.3.3 Method of test

The dosemeter shall be exposed to 20 single pulses each of:

a) t_{pulse} = 1 ms and $\dot{H}_{\text{pulse, 1}}$ = 0,7 × $\dot{H}_{\text{meas, max}}$ (pulse condition 1) and

b) t_{pulse} = 1 ms and $\dot{H}_{\text{pulse, 2}}$ = 1,3 × $\dot{H}_{\text{meas, max}}$ (pulse condition 2).

It shall be ensured that the dosemeter returns to its internal state relevant for measuring background or environmental radiation before the next measurement is performed. For the required waiting time, see 5.6. The number of pulse dose rate overload alarms shall be counted for both conditions.

NOTE 1 ms is chosen to be well measurable, delivering enough dose to be displayed and to be shorter than typical measurement cycle times, etc.

6.3.4 Interpretation of the results

If, for the 20 pulses with the pulse condition 1, two or less pulse dose rate overload alarms occur and if, for the 20 pulses with the pulse condition 2, 18 or more pulse dose rate overload alarms occur and if the pulse dose rate overload alarm is not deactivated automatically, then the requirements of 6.3.2 are fulfilled.

NOTE The uncertainty of the measured dose rate for the pulses is considered by allowing one more false alarm for pulse condition 1 and one less alarm for pulse condition 2.

6.4 Overload and pulse dose rate overload alarm

6.4.1 Requirements

Up to a pulse dose rate in the radiation pulse of 100 times $\dot{H}_{\text{meas, max}}$, or 1 000 Sv h^{-1} (= 277,8 µSv ms^{-1}) if this is smaller, the pulse overload alarm, if provided, shall be activated or, if not provided, the dose indication for a single pulse shall not be below the value obtained for the pulse with the pulse dose rate $\dot{H}_{\text{meas, max}}$.

NOTE This requirement aims to prevent an indication of a very low or even zero value in the overload condition if no overload alarm is provided.

6.4.2 Method of test

Expose the dosemeter with three different single radiation pulses (pulse conditions 1 to 3) of which the pulse duration, t_{pulse}, the dose per radiation pulse, H_{pulse}, and the pulse dose rate, $\dot{H}_{\text{pulse}}$, are well known. The pulses shall differ by the pulse dose rate, $\dot{H}_{\text{pulse}}$ but shall all have the same pulse duration, t_{pulse}. This duration shall be as short as possible but within the range tested in 6.2, e.g. 1 s. For the first pulse the pulse dose rate, $\dot{H}_{\text{pulse,1}}$, shall be equal to $\dot{H}_{\text{meas, max}}$. For the second pulse the pulse dose rate, $\dot{H}_{\text{pulse,2}}$, shall be equal to 10 times $\dot{H}_{\text{meas, max}}$ and for the third pulse the pulse dose rate, $\dot{H}_{\text{pulse,3}}$, shall be equal to 100 times $\dot{H}_{\text{meas, max}}$, or 1 000 Sv h^{-1}, whichever is smaller. With these parameters, at least 10 measurements for each pulse condition shall be performed, ensuring that the dosemeter returns to its internal state relevant for measuring background or environmental radiation before the next measurement is performed. For the required waiting time, see 5.6.

Determine the mean indications $G_{\text{dose, 1}}$ to $G_{\text{dose, 3}}$ for the four radiation pulses and note if the pulse dose rate overload alarm is activated for all the pulses with the conditions 2 and 3.

6.4.3 Interpretation of the results

If the relations

$G_{\text{dose, 2}} \geq G_{\text{dose, 1}}$

and

$G_{\text{dose, 3}} \geq G_{\text{dose, 1}}$

are fulfilled or the pulse dose rate overload alarm is activated for all pulses with the conditions 2 and 3, then the requirements of 6.4.1 are fulfilled.

7 Environmental requirements

No additional requirements for pulsed radiation.

NOTE These requirements are already stated in the IEC instrument specific standard.

8 Mechanical requirements

The manufacturer shall state if the dosemeter is provided with a capability for detecting mechanical shocks and if this results in discarding pulses that are assumed to be caused by mechanical shocks. If that is the case, this information shall be contained in the dosemeter's manual.

No additional requirements for pulsed radiation.

9 Electromagnetic requirements

The manufacturer shall state if the dosemeter is provided with a capability for detecting or distinguishing electromagnetic disturbances and if this results in discarding pulses that are assumed to be caused by electromagnetic disturbances. If that is the case, this information shall be contained in the dosemeter's manual.

No additional requirements for pulsed radiation.

10 Documentation

10.1 Operation and maintenance manual

Each instrument shall be supplied with operating instructions, maintenance and technical documentation as specified in the instrument specific standard. In addition, the following measurement results shall be given:

– The maximum measurable dose rate in the pulse, $\dot{H}_{\text{meas, max}}$,

– the maximum measurable dose in the pulse, $H_{\text{meas,max}}$,

– a figure of dose rate dependence of the response for pulsed radiation

– the minimal pulse duration, $t_{\text{meas,min}}$,

– the range for the pulse repetition frequency, $f_{\text{meas,min}}$ to $f_{\text{meas,max}}$,

– the time that the dosemeter requires to come back to its internal state relevant for measuring background or environmental radiation after any additional external radiation field is switched off, see 5.6,

– information according to Clauses 8 and 9.

Interrelations between e.g. maximum measurable dose rate and/or maximum measurable dose on the pulse duration and/or pulse repetition frequency may be given as a diagram or a function.

NOTE 1 The maximum dose rate in continuous radiation fields measurable by the dosemeter is stated in the documentation required by the instrument specific standard.

NOTE 2 An example for a figure of the dependence of the response on the dose rate can be found in Annex B, Figure B.2.

10.2 Type test report

Upon request, the manufacturer shall provide a report covering the type tests performed in accordance with the requirements of this document.

Table 2 – Reference conditions and standard test conditions for tests using pulsed radiation

Influence quantity	Reference conditions (unless otherwise indicated by the manufacturer)	Standard test conditions (unless otherwise indicated by the manufacturer)
Photon radiation energy	H-100 (ISO 4037-3) or RQR 8 (IEC 61267:2005)	H-100 (ISO 4037-3) or RQR 8 (IEC 61267:2005)
Angle of incidence of radiation	Reference direction given by the manufacturer	Direction given ±5°
Pulse duration	Continuous	≥ 10 s
Dose rate	100 mSv h^{-1}	50 mSv h^{-1} to 200 mSv h^{-1} [a)]
Time interval between measurements	As stated by the manufacturer, see 5.6	Longer than that stated by the manufacturer, see 5.6
a) The actual value of the dose (rate) at the time of test shall be stated.		

Table 3 – Characteristics of dosemeters used in pulsed fields of ionizing radiation

Line	Characteristic under test or influence quantity	Requirement or minimum rated range of influence quantity	Limit of variation of instrument parameter or relative response for whole rated range	Sub-clause
1	$\dot{H}_{\text{meas, max}}$	$\dot{H}_{\text{meas, max}} \geq 10\ \text{Sv h}^{-1}$	± 20 %	6.2 6.4
2	$H_{\text{meas, max}}$	$H_{\text{meas, max}} \geq 1\ \text{mSv}$	As defined for the dose in instrument specific standard	6.2
3	Pulse overload alarm, if provided	Set to $\dot{H}_{\text{meas, max}}$	$\dot{H}_{\text{pulse, 1}} = 0{,}7 \times \dot{H}_{\text{meas, max}}$: Alarm activated ≤ 5 % of pulses $\dot{H}_{\text{pulse, 2}} = 1{,}3 \times \dot{H}_{\text{meas, max}}$: Alarm activated ≥ 95 % of pulses	6.3
4	Dose rate overload for dose measurement	$\dot{H}_{\text{meas, max}} \leq 100 \times \dot{H}_{\text{meas, max}}$ or 1 000 Sv h^{-1} if this is smaller	Dose indication greater than that obtained for $\dot{H}_{\text{meas, max}}$ or overload alarm	6.4