TECHNICAL SPECIFICATION

ISO/TS 18090-1

First edition
2015-08-01

Radiological protection — Characteristics of reference pulsed radiation —

Part 1: Photon radiation

Radioprotection — Caractéristiques des champs de rayonnement pulsés de référence —

Partie 1: Radiation de photons

Reference number
ISO/TS 18090-1:2015(E)

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 2, *Radiological protection*.

ISO/TS 18090 consists of the following parts, under the general title *Radiological protection — Characteristics of reference pulsed radiation*:

— *Part 1: Photon radiation*

Introduction

The specification and determination of the special characteristics required for radiation protection dosemeters to be used in pulsed fields of ionizing radiation have been excluded from all International Standards for personal and environmental dosemeters issued so far. Due to the increased use of pulsed radiation in medicine and industry, such International Standards are currently under development. A prerequisite for such International Standards is the availability of the required reference fields for pulsed radiation. This Technical Specification provides the necessary information for such reference fields.

The concept is based on the existing standards for radiation qualities defined in ISO and IEC standards. It only adds the parameters of the pulsed field and gives some guidance for their determination. Therefore, no new radiation qualities are defined, only the link between the parameters for pulsed radiation and the parameters for continuous radiation are given. The main required parameters for pulsed radiation fields are the following:

— radiation pulse duration, t_{pulse};

— radiation pulse air kerma rate, $\dot{K}_{a,pulse}$;

— air kerma per radiation pulse, $K_{a,pulse}$;

— for repeated pulses, their repetition frequency, f_{pulse}.

The pulse parameters were determined by using an equivalent trapezoidal radiation pulse, which is equivalent with respect to air kerma and air kerma rate. Reference pulsed radiation is characterized by specified maximum deviations of the given pulse from the equivalent trapezoidal radiation pulse and by requirements concerning the change of radiation quality during the given radiation pulse.

The pulse parameters with respect to the phantom related quantities were determined using conversion coefficients according to ISO 4037 (all parts).

This publication contains 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 following years, experience will be gained and the maintenance of this Technical Specification could lead to an International Standard.

Radiological protection — Characteristics of reference pulsed radiation —

Part 1: Photon radiation

1 Scope

This part of ISO/TS 18090 is directly applicable to pulsed X-radiation with pulse duration of 0,1 ms up to 10 s. This covers the whole range used in medical diagnostics at the time of publication. Some specifications may also be applicable for much shorter pulses; one example is the air kerma of one pulse. Such a pulse may be produced, e.g. by X-ray flash units or high-intensity femtosecond-lasers. Other specifications are not applicable for much shorter pulses; one example is the time-dependent behaviour of the air kerma rate. This may not be measurable for technical reasons as no suitable instrument is available, e.g. for pulses produced by a femtosecond-laser.

This part of ISO/TS 18090 specifies the characteristics of reference pulsed radiation for calibrating and testing radiation protection dosemeters and dose rate meters with respect to their response to pulsed radiation. The radiation characteristics includes the following:

a) time-dependent behaviour of the air kerma rate of the pulse;

b) time-dependent behaviour of the X-ray tube high voltage during the pulse;

c) uniformity of the air kerma rate within a cross-sectional area of the radiation beam;

d) air kerma of one radiation pulse;

e) air kerma rate of the radiation pulse;

f) repetition frequency.

This part of ISO/TS 18090 does not define new radiation qualities. Instead, it uses those radiation qualities specified in existing ISO and IEC standards. This part of ISO/TS 18090 gives the link between the parameters for pulsed radiation and the parameters for continuous radiation specifying the radiation qualities. It does not specify specific values or series of values for the pulsed radiation field but specifies only those limits for the relevant pulsed radiation parameters that are required for calibrating dosemeters and dose rate meters and for determining their response depending on the said parameters.

The pulse parameters with respect to the phantom-related quantities were determined using conversion coefficients according to ISO 4037 (all parts). This is possible as the radiation qualities specified in existing ISO and IEC standards are used.

A given reference pulsed X-ray facility is characterized by the parameter ranges over which the full specifications and requirements according to this part of ISO/TS 18090 are met. Therefore, not all reference pulsed X-ray facilities can produce pulses covering the same parameter ranges.

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.

ISO 4037-1:1996, *X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy — Part 1: Radiation characteristics and production methods*

ISO 4037-2:1997, *X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy — Part 2: Dosimetry for radiation protection over the energy ranges from 8 keV to 1,3 MeV and 4 MeV to 9 MeV*

IEC 60050-395:2014, *International Electrotechnical Vocabulary — 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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-395:2014 and the following apply.

3.1
air kerma per radiation pulse
$K_{\text{a, pulse}}$
air kerma value of one radiation pulse at a point in the photon radiation field

3.2
continuous radiation
<in area and individual dosimetry> ionizing radiation with a constant dose rate at a given point in space for time intervals longer than 10 s

3.3
dose equivalent per radiation pulse
H_{pulse}
dose equivalent value of one radiation pulse at a point in the photon radiation field

3.4
equivalent trapezoidal radiation pulse
trapezoidal radiation pulse that is considered to be equivalent to the given radiation pulse

3.5
field uniformity
F_{uni}
uniformity of the air kerma distribution determined across a defined area

$$F_{\text{uni}} = 1 - \frac{K_{\text{a, pulse, max}} - K_{\text{a, pulse, min}}}{0{,}5 \times \left(K_{\text{a, pulse, max}} + K_{\text{a, pulse, min}} \right)}$$

where

$K_{\text{a, pulse, max}}$ is the maximum air kerma value attributed to one radiation pulse occurring across the defined area;

$K_{\text{a, pulse, min}}$ is the minimum air kerma value attributed to one radiation pulse occurring across the defined area.

Note 1 to entry: The defined area can be the whole beam diameter or only parts of it, e.g. those covered by the dosemeter under test.

Note 2 to entry: Full field uniformity is equivalent to $F_{\text{uni}} = 1$. No field uniformity, that is a variation of $K_{\text{a, pulse}}$ between 0 and $K_{\text{a, pulse, max}}$, is equivalent to $F_{\text{uni}} = 0$.

3.6
pulse peak mean voltage
$U_{\text{pulse, peak, mean}}$
mean value of the sequence of X-ray tube voltages, U_i, measured during the radiation pulse peak time

$$U_{\text{pulse, peak, mean}} = \frac{1}{n_{\text{peak}}} \sum_{i=1}^{n_{\text{peak}}} U_i$$

where

U_i is the i-th measured value;

n_{peak} is the number of measurements of the X-ray tube voltage.

3.7
pulse repetition frequency
f_{pulse}
number of pulses in a periodic pulse train divided by the duration of the train

[SOURCE: IEV 702-03-07, modified]

Note 1 to entry: This version of this part of ISO/TS 18090 deals only with single pulses, but it might be extended in the future to repeated pulses, therefore, this definition is already given here.

3.8
pulse train
discrete sequence of a finite number of pulses

[SOURCE: IEV 702-03-11, modified]

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

3.9
pulsed radiation
<in 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

3.10
radiation pulse base duration
radiation pulse base width
$t_{\text{pulse, base}}$
interval of time between the first and last instants at which the instantaneous air kerma rate value of the equivalent trapezoidal pulse deviates from zero

Note 1 to entry: The value zero of the equivalent trapezoidal pulse is equal to the baseline of the measured pulse.

3.11
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

3.12
radiation pulse fall time
$t_{\text{pulse, fall}}$
interval of time between the last instants at which the instantaneous air kerma rate value of the equivalent trapezoidal pulse reaches 80 % and 20 % of its maximum value

3.13
radiation pulse air kerma rate

$\dot{K}_{\text{a,pulse}}$

quotient of the air kerma per radiation pulse and the radiation pulse duration at a point in the photon radiation field

Note 1 to entry: The air kerma per radiation pulse can be measured either by an integral measurement with an ionization chamber or time resolved by a suitable instrument, both calibrated in terms of air kerma.

3.14
radiation pulse dose equivalent rate

$\dot{H}_{\text{a, pulse}}$

quotient of the dose equivalent per radiation pulse and the radiation pulse duration at a point in the photon radiation field

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

3.15
radiation pulse peak voltage ripple

$U_{\text{pulse, peak, ripple}}$

standard deviation of the sequence of X-ray tube voltages, U_i, measured during the radiation pulse peak time

$$U_{\text{pulse, peak, ripple}} = \sqrt{\frac{1}{n_{\text{peak}} - 1} \sum_{i=1}^{n_{\text{peak}}} \left(U_i - U_{\text{pulse, peak, mean}} \right)^2}$$

where

U_i	is the i-th measured value of the X-ray tube voltage;
n_{peak}	is the number of measurements;
$U_{\text{pulse, peak, mean}}$	is the pulse peak mean voltage.

3.16
radiation pulse peak time
pulse peak time

$t_{\text{pulse, peak}}$

interval of time between the first and last instants at which the instantaneous air kerma rate value of the equivalent trapezoidal pulse reaches 80 % of its maximum value

Note 1 to entry: The radiation pulse peak time is the interval of time between the end of the rise time and the beginning of the fall time of the equivalent trapezoidal pulse.

3.17
radiation pulse plateau time

$t_{\text{pulse, plateau}}$

interval of time at which the instantaneous air kerma rate value of the equivalent trapezoidal pulse reaches its maximum value

3.18
radiation pulse rise time

$t_{\text{pulse, rise}}$

interval of time between the first instants at which the instantaneous air kerma rate value of the equivalent trapezoidal pulse reaches 20 % and 80 % of its maximum value

3.19
trapezoidal pulse
unidirectional pulse having a constant gradient during increase from zero to its maximum value, remains for a given time at this maximum value and having a constant gradient during its decrease from the maximum value to zero

Note 1 to entry: See Figure 1.

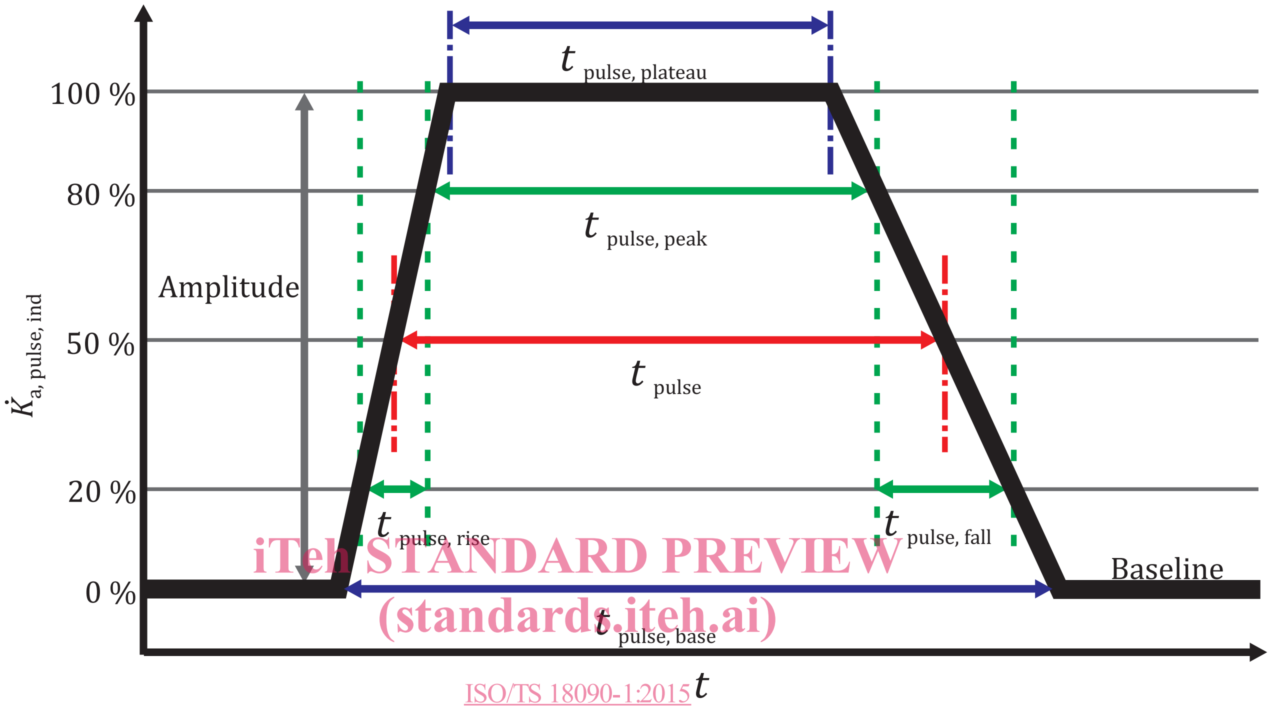

Figure 1 — Equivalent trapezoidal radiation pulse with the relevant parameters

4 Characteristics of reference pulsed radiation

4.1 General

The characterization of the radiation pulse requires the time resolved measurement of the air kerma rate and the tube high voltage during the pulse and the space resolved measurement of the air kerma of the pulse. In general, these measurements cannot be done with one single instrument.

4.2 Time-dependent air kerma rate characteristics of the radiation pulse

4.2.1 Requirements

The pulse rise time plus the pulse fall time shall not exceed 0,6 times the pulse duration:

$$t_{\text{pulse, rise}} + t_{\text{pulse, fall}} \leq 0{,}6 \times t_{\text{pulse}} \quad (1)$$

The time resolved indicated values of the air kerma pulse rate, $\dot{K}_{\text{a,pulse, ind}}$, and the radiation pulse duration, t_{pulse}, shall be determined.