# Ideas for type tests of electronic dosemeters in pulsed fields

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# Motivation

It has been proofed, that electronic area and personal dosemeter may fail if they are used in pulsed radiation fields.

U. Ankerhold, O. Hupe and P. Ambrosi:
Deficiencies of active electronic radiation protection dosemeters in pulsed fields
Radiation Protection Dosimetry Vol. 135, No. 3, pp. 149-153 (2009)

Up to now there are no type test requirements for the use in pulsed radiation fields.

This work is supported by a German project:
Innovation with Norms and Standards (INS) of the German Commission for Electrical, Electronic & Information Technologies (DKE).

# General considerations

In principle, tests in continuous radiation fields are sufficient, if the detector is connected to a simple, linear and straight forward counting electronics.

**But** dosemeters

- use internal range switching,
- use software to correct for known deficiencies, e.g., the dead time or the radiation energy,
- use special, unknown algorithms,
- adjust the measurement cycle time, $T_{cycle}$, to the dose rate,
- suppress EMC-pulses and mechanical drops.

Measurements using pulsed radiation are necessary

# Response of an APD to pulsed radiation (≠ cw)

RQR8

**Constant dose in the pulse (~1 mSv)**, but
**different pulse duration / dose rate in the pulse**

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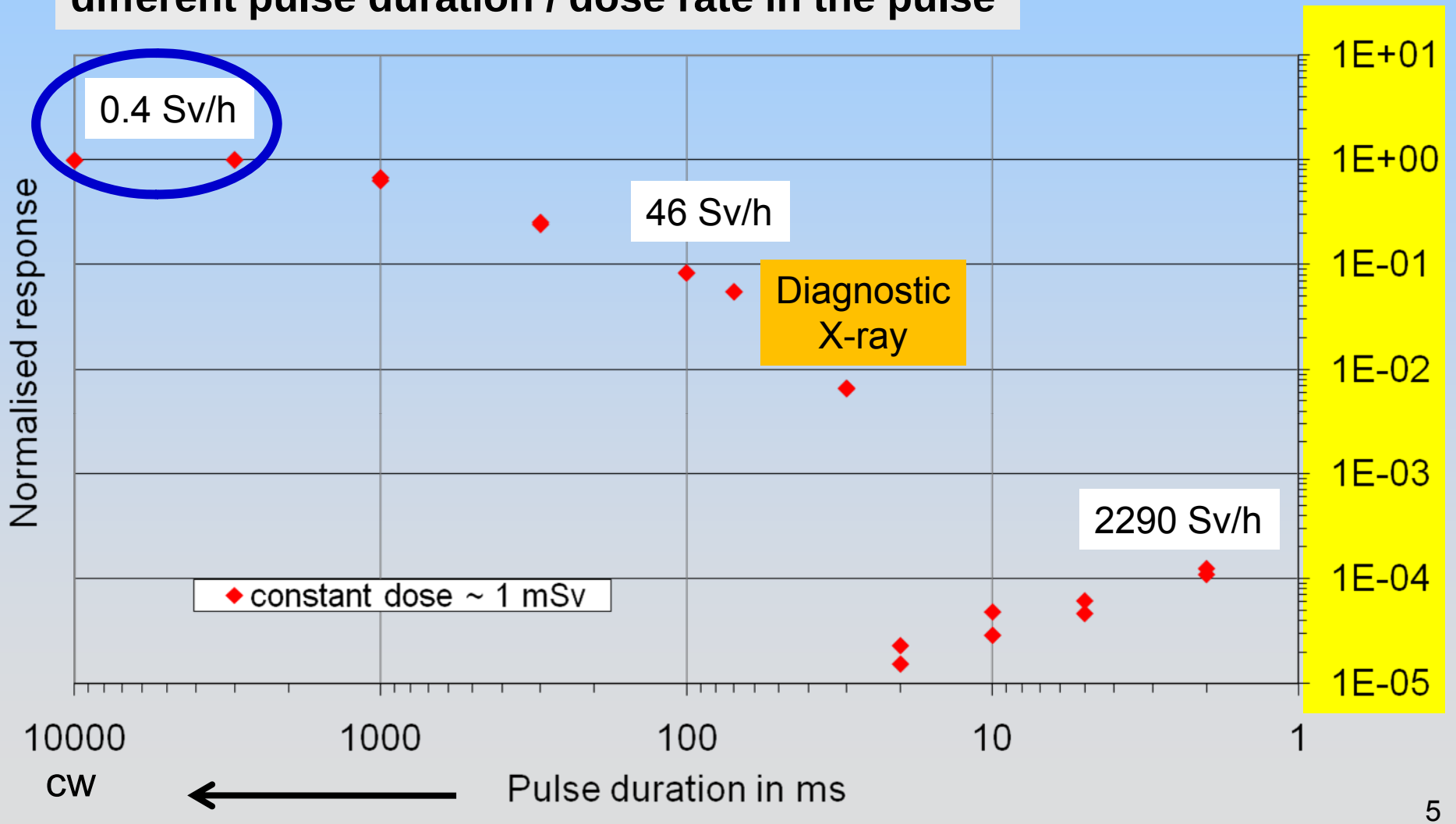

# Response of an EPD to pulsed radiation (≠ cw)

RQR8

**Constant dose rate in the pulse**, but **different pulse duration**

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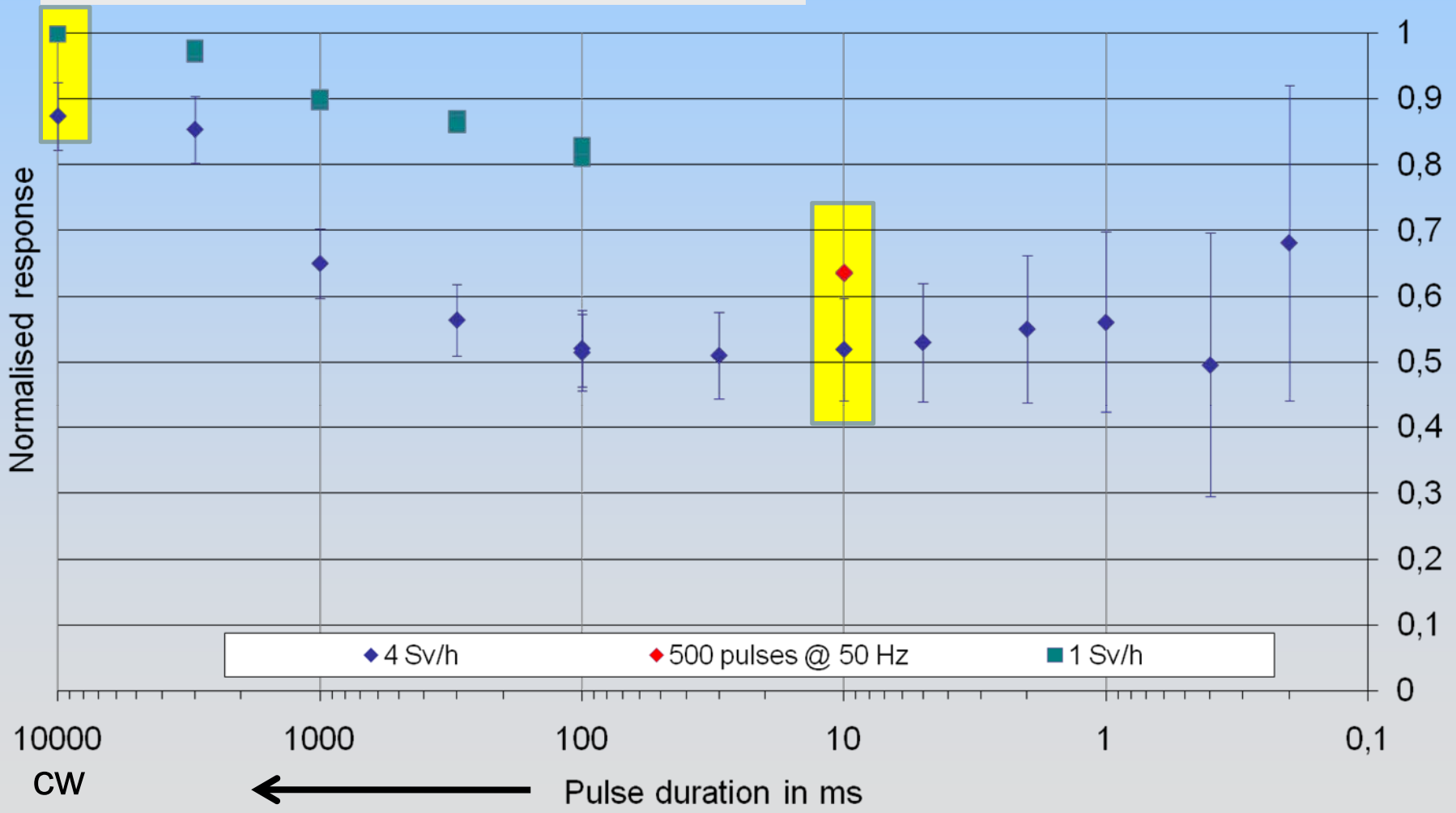

# Concept of the new standard

The concept is similar to the concept used for other influence quantities, e.g., radiation energy.

The user must know the parameter range of the pulsed field at the workplace, i.e., in the case of the parameter particle energy its possible values.

Then the user can judge whether or not the dosemeter under consideration can be used.

# Required parameters

… for pulsed radiation fields are

- the minimal radiation pulse duration, $t_{\text{pulse, min}}$,
- the maximum dose rate during the radiation pulse, $\dot{H}_{\text{pulse, max}}$
- the maximum dose per radiation pulse, $H_{\text{pulse, max}}$,
- the maximum repetition frequency of the radiation pulses, $f_{\text{pulse, max}}$.

To avoid confusion:
pulse: always property of the radiation field
count: always property of the dosemeter

# Required parameters

… to be known of the counting dosemeter are

- the dead time of the detector, $t_{dead}$,
- the maximum measurable dose rate in the pulse, $\dot{H}_{count,\,max}$
- the dose indication per counting event, $G_{count}$,
- the type of the dead time, i.e., extendable or non-extendable,
- the measurement cycle time, $T_{cycle}$.

To avoid confusion:
pulse: always property of the radiation field
count: always property of the dosemeter

# Requirements for the pulsed radiation source

The pulsed radiation test source shall be adjustable with respect to the parameters:

- radiation pulse duration, $t_{pulse}$,
- dose rate during the radiation pulse, $\dot{H}_{pulse}$
- dose per radiation pulse, $H_{pulse}$,
- repetition frequency of the radiation pulses, $f_{pulse}$.

To avoid confusion:
pulse: always property of the radiation field
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# Novel pulsed radiation source at PTB

## NOVEL PULSED X-RAY FACILITY FOR RESEARCH AND TYPE TESTING

Jana Klammer*, Oliver Hupe and Jürgen Roth
Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig, Germany

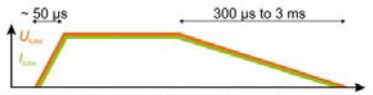
### Introduction

The application of pulsed radiation fields for medical investigations has increased remarkably in the last years. But until today, radiation protection dosemeters have only been tested in continuous fields, as shown by Ankerhold et al.. The characteristics of dosemeters determined in continuous fields cannot be transferred to those in pulsed radiation fields. Therefore, a reference field for pulsed radiation is needed. Such novel X-ray equipment has been installed at PTB for research and type testing of personal and area dosemeters.

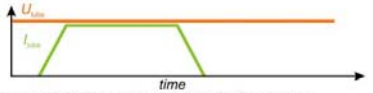
References:
Ankerhold, U., Hupe, O. and Ambrosi, P. Deficiencies of active electronic radiation protection dosemeters in pulsed fields. Radiat. Prot. Dosim. 135, No. 3, 149-153 (2009).

### Properties of the new X-ray facility for pulsed radiation

All relevant field parameters, like pulse duration, tube voltage, and current can be varied independently with small uncertainty.



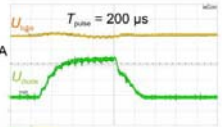

Generator-controlled X-ray tube in standard medical X-ray equipment.




Grid-controlled X-ray tube in the novel pulsed X-ray facility.

The new X-ray facility for pulsed radiation has been developed in co-operation with Siemens AG Sector Healthcare and ESW GmbH.

- Tube voltage 40 kV to 125 kV
- Tube current 0.5 mA to 800 mA
- Pulse duration 0.2 ms to cw
- Max el. power up to 80 kW
- $f_{pulse}$ up to 100 Hz




All these parameters are adjustable!

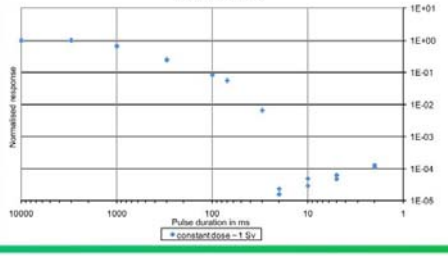
### Measurement equipment for characterisation

- Secondary standard ion chambers for $H^*(10)$ and $H_p(10)$
- Additional external high voltage divider for measurement
- Traceable to primary standards
- Pulse form measurement with semiconductor diodes

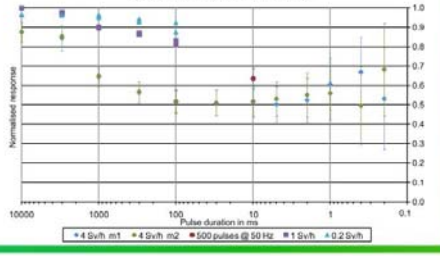
### Preliminary results on first tests in pulsed fields

A electronic personal dosemeter type EPD Mk2.3 was tested under pulsed conditions. First we varied the pulse duration of single pulses for a constant dose of approx. 1 Sv (see left diagram). Then we varied the pulse duration at a **constant** maximum dose rate during the radiation pulse of approx. **4 Svh**$^{-1}$ (see right diagram).

Constant dose




Constant maximum dose rate

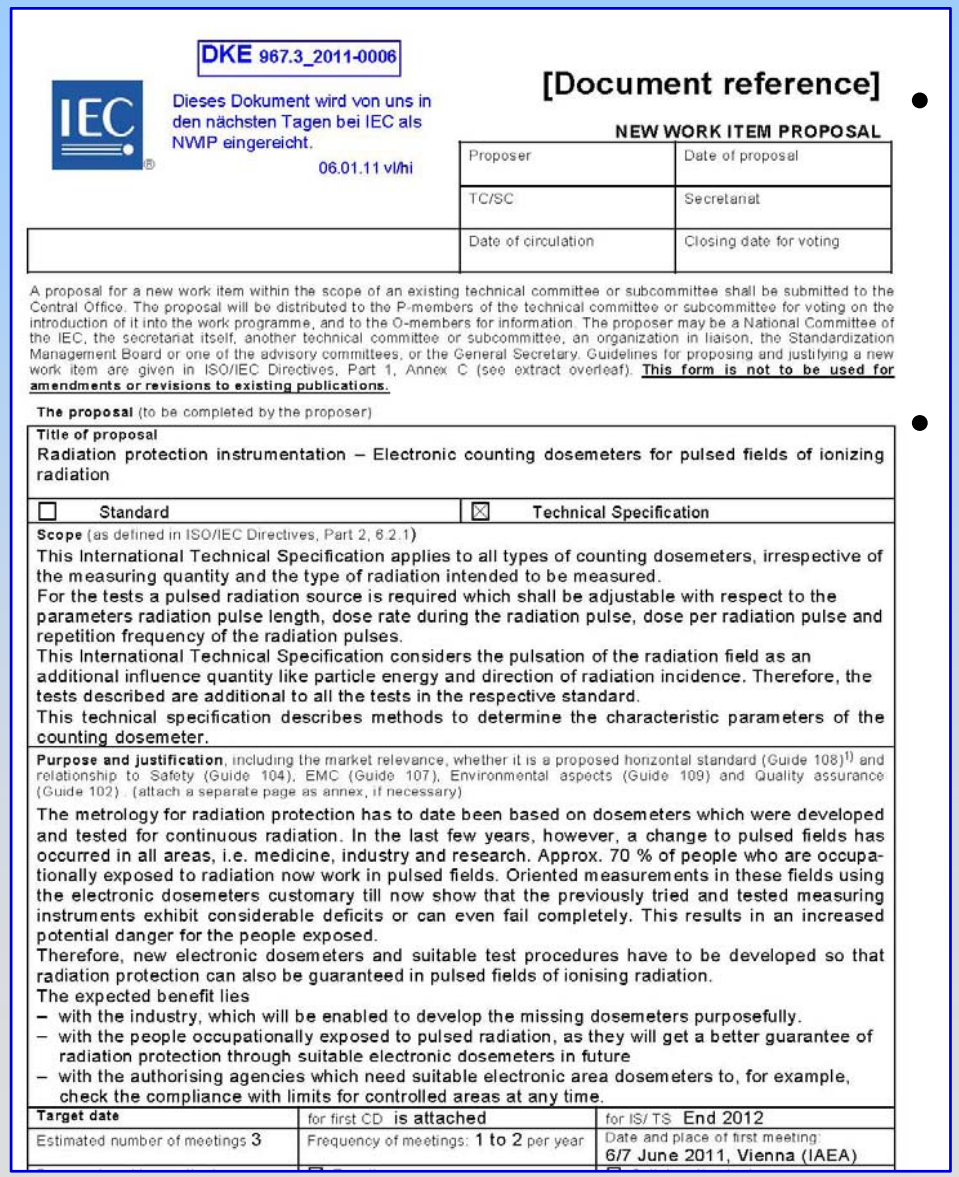



### Status

- Pulsed X-ray equipment has been installed, tested and characterized (energy spectrum, field distribution, dose rate, pulse duration)
- Grid-controlled X-ray tube allows pulses without an "energy ramp"
- Each parameter can be adjusted
- Pulse duration can be varied from 0.2 ms to continuous radiation
- N-series and RQR-qualities have been installed

Poster P2:
J. Klammer et al.

# Now & Future



DKE 967.3_2011-0006

Dieses Dokument wird von uns in den nächsten Tagen bei IEC als NWIP eingereicht.

06.01.11 vl/hi

[Document reference]

**NEW WORK ITEM PROPOSAL**

| Proposer | Date of proposal |
|---|---|
| TC/SC | Secretariat |
| Date of circulation | Closing date for voting |

A proposal for a new work item within the scope of an existing technical committee or subcommittee shall be submitted to the Central Office. The proposal will be distributed to the P-members of the technical committee or subcommittee for voting on the introduction of it into the work programme, and to the O-members for information. The proposer may be a National Committee of the IEC, the secretariat itself, another technical committee or subcommittee, an organization in liaison, the Standardization Management Board or one of the advisory committees, or the General Secretary. Guidelines for proposing and justifying a new work item are given in ISO/IEC Directives, Part 1, Annex C (see extract overleaf). **This form is not to be used for amendments or revisions to existing publications.**

**The proposal** (to be completed by the proposer)

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

☐ Standard ☒ Technical Specification

**Scope** (as defined in ISO/IEC Directives, Part 2, 6.2.1)
This International Technical Specification applies to all types of counting dosemeters, irrespective of the measuring quantity and the type of radiation intended to be measured.
For the tests a pulsed radiation source is required which shall be adjustable with respect to the parameters radiation pulse length, dose rate during the radiation pulse, dose per radiation pulse and repetition frequency of the radiation pulses.
This International 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 standard.
This technical specification describes methods to determine the characteristic parameters of the counting dosemeter.

**Purpose and justification**, including the market relevance, whether it is a proposed horizontal standard (Guide 108)[1] and relationship to Safety (Guide 104), EMC (Guide 107), Environmental aspects (Guide 109) and Quality assurance (Guide 102). (attach a separate page as annex, if necessary)
The metrology for radiation protection has to date been based on dosemeters which were developed and tested for continuous radiation. In the last few years, however, a change to pulsed fields has occurred in all areas, i.e. medicine, industry and research. Approx. 70 % of people who are occupationally exposed to radiation now work in pulsed fields. Oriented measurements in these fields using the electronic dosemeters customary till now show that the previously tried and tested measuring instruments exhibit considerable deficits or can even fail completely. This results in an increased potential danger for the people exposed.
Therefore, new electronic dosemeters and suitable test procedures have to be developed so that radiation protection can also be guaranteed in pulsed fields of ionising radiation.
The expected benefit lies
– with the industry, which will be enabled to develop the missing dosemeters purposefully.
– with the people occupationally exposed to pulsed radiation, as they will get a better guarantee of radiation protection through suitable electronic dosemeters in future
– with the authorising agencies which need suitable electronic area dosemeters to, for example, check the compliance with limits for controlled areas at any time.

| **Target date** | for first CD is attached | for IS/ TS End 2012 |
|---|---|---|
| Estimated number of meetings 3 | Frequency of meetings: 1 to 2 per year | Date and place of first meeting: 6/7 June 2011, Vienna (IAEA) |

- New work item proposal for a TAS has been send to IEC.
- New work item proposal for an ISO standard on pulsed fields of ionizing radiation is in preparation.

# Radiation detection requirements

Model function of the dosemeter

$$G_{\text{dose}} = K \cdot G_{\text{count}} \cdot n_{\text{count}} \cdot k_{\text{dead, int}}$$

Model function of the doseratemeter

$$\dot{G}_{\text{dose}} = \frac{G_{\text{dose}}}{T_{\text{cycle}}}$$

| | |
|---|---|
| $G_{\text{dose}}$ : | dose indication of the dosemeter |
| $K$ : | product of all correction factors, except $k_{\text{dead,int}}$ |
| $G_{\text{count}}$ : | dose indication per counting event of the dosemeter |
| $n_{\text{count}}$ : | number of counting events counted by the dosemeter |
| $k_{\text{dead, int}}$ : | correction factor for dead time internal to the dosemeter |
| $T_{\text{cycle}}$ : | measurement cycle time of the dosemeter |

# Structure of the proposed NWIP

1 Scope
2 Normative references
3 Terms and definitions, abbreviations and symbols, quantities and units
4 General test procedure
5 General requirements
6 Radiation detection requirements
7 Environmental requirements
8 Mechanical requirements
9 Electromagnetic requirements
10 Documentation

Annex A: Parameter values for typical workplaces where pulsed radiation occurs (for the decision if dosemeter can be used)

Annex B: Parameters characterizing the pulsed radiation field (↔ ISO)

# Can I help you? How can I help?

IEC is not a closed circle

**IEC needs your experience**

All interested persons are welcome!

# Thank you for your attention!

# End!

U. Ankerhold, O. Hupe and P. Ambrosi:
Deficiencies of active electronic radiation protection dosemeters in pulsed fields
Radiation Protection Dosimetry Vol. 135, No. 3, pp. 149-153 (2009)

P. Ambrosi, Borowski, M. and Iwatschenko, M.:
Considerations concerning the use of counting active personal dosemeters in pulsed fields of ionising radiation
Radiation Protection Dosimetry Vol. 139, No. 4, pp. 483-493 (2010)

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