

On the response of electronic personal dosimeters in constant potential and pulsed x- ray beams

M.C. Guimarães, C.R.E. Silva, P.M.C. Oliveira¹, T.A. da Silva

Centro de Desenvolvimento da Tecnologia Nuclear, CDTN
Av. Presidente Antônio Carlos 6627, Pampulha
31270-901 Belo Horizonte, MG, Brazil

¹Faculdade de Medicina – Universidade Federal de Minas Gerais, UFMG
Av. Prof. Alfredo Balena, 190, Funcionários
30130-100 Belo Horizonte, MG, Brazil

E-mail: margaretecristinag@gmail.com, silvata@cdtn.br

Abstract. Electronic personal dosimeters (EPDs) based on solid state detectors have widely been used but some deficiencies in their response in pulsed radiation beams have been reported. Nowadays, there is not an international standard for pulsed x-ray beams for calibration or type testing of dosimeters. Irradiation conditions for testing the response of EPDs in both the constant potential and pulsed x-ray beams were established in CDTN. Three different types of EPDs were tested in different conditions in similar ISO and IEC x-ray qualities. Results stressed the need of performing additional checks before using EPDs in constant potential or pulsed x-rays.

1. Introduction

Radiation protection requires that individual monitoring should be done by reliable dosimeters. The ISO and IEC standards established the performance requirements for the response and calibration of electronic dosimeters in reference constant potential x-ray beams [1]. Electronic personal dosimeters (EPDs) based on solid state detectors have widely been used but some deficiencies in their response in pulsed radiation beams have been reported [2]. Nowadays, there is not an international standard for pulsed x-ray beams for calibration or type testing of dosimeters. In Brazil, reliability of dosimeters is based only in their calibration in a standard ¹³⁷Cs gamma beam. Performance checks or type testing of radiation protection dosimeters are not legally required but they are informally performed in some Brazilian metrology laboratories for academic studies [3].

The objective of this work was to study the response of some electronic dosimeters in reference constant potential x-ray qualities and in pulsed x-ray beams.



2. Materials and Methodology

The established irradiation conditions for testing dosimeters in both constant potential and pulsed x-ray beams of the Dosimeter Calibration Laboratory, LCD/CDTN, were used. ISO and IEC reference radiations were reproduced in a 320HS constant potential Seifert-Pantak and in an 800 Pulsar Plus VMI medical x-ray machines.

A Xi light UNFORS solid state dosimetric system and a 10X6 RADCAL ionization chamber were used as reference dosimeters to measure the air kerma free in air at the reference calibration point. The performance of both reference dosimeters were already studied in all x-ray beams (Guimarães et al, 2013).

The dosimeters RAD-60 RADOS, PDM-111 ALOKA and EPD-MK2 THERMOELECTRON were calibrated in ^{137}Cs beam and then tested according to their operation ranges in x-rays, in terms of the personal dose equivalent, $\text{Hp}(10)$. The true conventional value of $\text{Hp}(10)$ was determined based on the air kerma value free in air and conversion coefficients to $\text{Hp}(10)$. Each EPD was positioned on the ISO standard slab phantom in the continuous x-ray beams of the Seifert Pantak machine (Figure 1).



Figure 1- Irradiation set-up for testing the electronic personal dosimeters in a constant potential x-ray machine.

Dosimeters were also tested in pulsed x-ray beams of the VMI medical machine on the ISO slab phantom. The Xi light UNFORS dosimeter was positioned on the surface of the slab phantom almost out of the radiation field to monitor the exposure (Figure 2).



Figure 2 - Irradiation set-up for testing the electronic personal dosimeters in pulsed X-rays of a medical machine.

3. Results and discussions

3.1. Calibration of the EPDs in ^{137}Cs gamma beam

The response of the EPDs was analyzed in terms of relative intrinsic error, i.e., the deviation of the response relatively to the conventional true value of Hp(10) that was determined with the reference dosimeter. The performance of EPDs as far their calibration in ^{137}Cs gamma radiation showed that the relative intrinsic errors were within the acceptable limit of 10% for all dosimeters.

3.2. Performance of EPDs in constant potential X-ray beams

RQA IEC X-ray qualities and N-series ISO reference radiations that were implemented in LCD/CDTN were chosen for testing the EPDs (Table 1).

The response of the EPDs in terms of their intrinsic error relative to Hp(10) showed that even within their range of operation some EPDs did not comply with acceptable limit of $\pm 30\%$ for energy dependence (Figure 3).

Table 1 - IEC and ISO X-ray qualities used for testing the electronic personal dosimeters in constant potential X-ray beams.

Radiation quality code	Tube voltage (kV)	Additional filtration (mm)	Mean energy (keV)
RQA-5	70	21.0 Al	51.2
RQA-7	90	30.0 Al	62.4
RQA-9	120	40.0 Al	75.8
N-60	60	0.49 Cu+3.18 Al	46.3
N-80	80	1.51 Cu+3.18 Al	62.7
N-100	100	4.00 Cu+3.18 Al	80.6

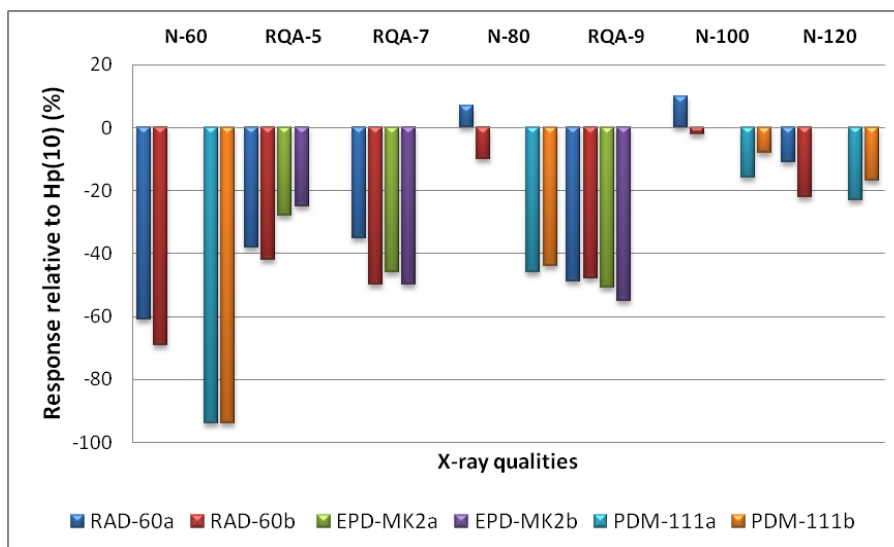


Figure 3 -- Response relative to Hp(10) of EPDs in constant potential X-ray beams.

3.3. Performance of EPDs in pulsed X-ray beams

X-ray beams similar to the RQA-5, 7 and 9 IEC qualities were reproduced in the 800 Pulsar Plus. VMI medical machine. EPDs were exposed to the beam conditions of 150 mA and 50 ms. The response of the EPDs in terms of the intrinsic error relative to Hp(10) is shown in Figure 4.

Results of the EPDs response in those pulsed beams showed that they maintained the trend of underestimation the Hp(10) value. One EPD did not respond at all to radiation and the others showed the same performance as in constant potential beams.

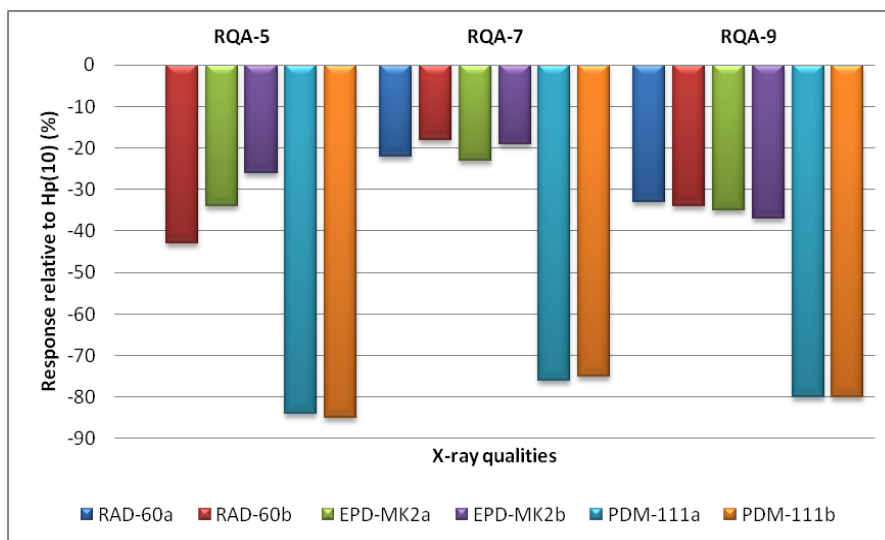


Figure 4 - Response relative to Hp(10) of EPDs in pulsed X-ray beams.

4. Conclusions

The results showed that even a well-calibrated EPDs might present an inadequate response to radiation energies lower than that from ^{137}Cs beam calibration condition. The performance of EPDs in pulsed beams was not conclusive, but the results suggested that studies for different exposure times would be important to be done.

This work stressed the need of performing additional checks before using EPDs that were only calibrated in ^{137}Cs radiation beam.

References

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