



Portuguese Health Physics Society: Calibrating Pen Dosimeters with and without a Phantom

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Abstract. Thirty one direct reading dosimeters (pen dosimeters) were calibrated and tested in standard beams of gamma radiation, with and without the use of a phantom. The calibration was performed with a ^{60}Co source and tested with a ^{137}Cs source. The dose-response curves of the pen dosimeters and their calibration factors for a ^{60}Co source, with and without the use of a phantom were obtained. The results show the need to calibrate the pen dosimeters with a phantom.

1 Introduction

Persons who are occupationally exposed to radiation have to be monitored in accordance to the recommendation of ICRP 60; in Brazil, the national standard "Basic Guidelines for Radiological Protection" determined by the Brazilian Commission of Nuclear Energy (CNEN) is used too. The individual monitoring controls the exposures, and estimates the doses received by the radiation workers. The ICRP recommends the exposure limits that ensure the health of the workers [1-2]. The individual dosimeters may be used to measure the exposures of the whole body or of the extremities. One of them is an additional dosimeter, the pen dosimeter. This instrument has a size of a pen pocket with an ionization chamber. These kinds of detectors are still very used in Brazil to measure accumulated doses or quantities of X and gamma radiation [3]. The objective of this work was to study the influence of the use of a phantom during the calibration of pen dosimeters with gamma radiation sources.

2 Materials and Methods

Thirty one pen dosimeters of three different manufactures and four different models were calibrated and tested with and without the use of a phantom in standard gamma radiations. Their characteristics are presented in Table 1. They were divided per use time: old and new pens.

Table 1. Characteristics of the pen dosimeters calibrated in this work

Manufacturer	Model	Code of old pens	Code of new pens
Arrow-tech	138	1-6	14-31
Victoreen	541L	7-8	-
Phy	Seq-5	9-11	-
	Seq-6	12-13	-

The instruments were initially calibrated with and without the presence of a slab phantom, using a ^{60}Co source of the gamma irradiator IPEN, serial number IR – 003, named A, shown in Figure 1.a. Afterwards, they were tested with a ^{137}Cs source from another gamma irradiator, manufactured by Steuerungstechnik & Strahlenschutz GmbH, model OB85, named B, shown in Figure 1.b. The beam dosimetry of the gamma radiation ^{137}Cs source was performed using an ionization chamber from Physikalisch-Technische Werkstätten (PTW), model W32002 – 035, calibrated at the National Laboratory for Ionizing Radiation Metrology (LNMRI), Rio de Janeiro, Brazil. The characteristics of the gamma irradiators are presented in Table 2.

The slab phantom, with dimensions of 300 mm x 300 mm x 150 mm, was developed at IPEN to represent the human torso (used for the calibration of whole body dosimeters) [4]. The calibration procedure of pen dosimeters with and without phantom is shown in Figures 2.a and 2.b.

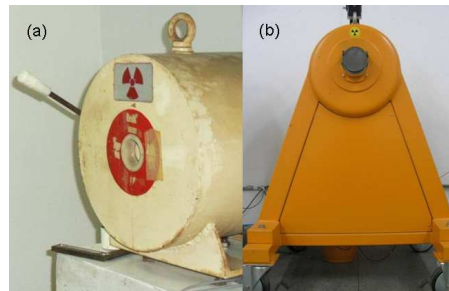


Fig. 1. The gamma irradiators IPEN, named A (a) and from Steuerungstechnik & Strahlenschutz GmbH, named B (b)

Table 2. Characteristics of the gamma radioactive sources utilized in this work

Irradiator	Radiation	Source	Activity	Calibration Date
A	gamma	^{60}Co	108.90 GBq	01/2002
B	gamma	^{137}Cs	470.00 GBq	05/1995

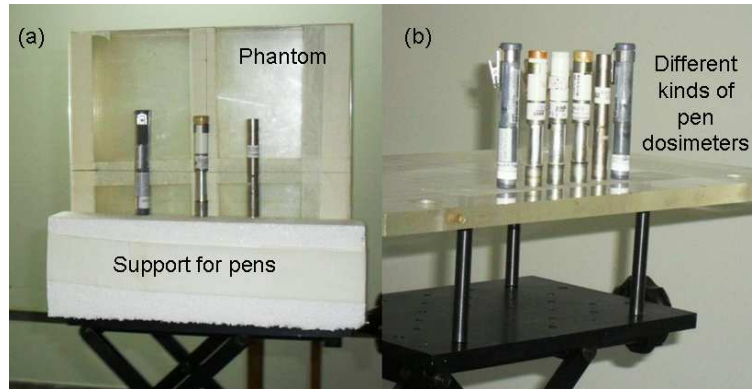


Fig. 2. Calibration of pen dosimeters with (a) and without (b) phantom

The measurements were taken with and without the presence of the slab phantom, and dose-response curves were obtained to compare the results. Afterwards, the calibration factors were obtained in a ^{60}Co beam, with and without the presence of the slab phantom. The calibration method was the use of known fields. The pen dosimeters were aligned with the radiation field in each case. The calibration factor (N) is determined by the ratio between the conventional true value (R) and the measured (M) value by the radiation detector, according to [4]:

$$N = \frac{R}{M}. \quad (1)$$

The uncertainties of the measurements were determined in accordance with the recommendations of Gonçalves and Souza [5].

3 Results

The results for the old pens were not totally satisfactory. Many of them did not show any differences at all on their responses when using or not the phantom. Most of the new pens showed good results. In this work, some results (dose-response curves) from old and new pens were chosen for presentation in Figures 3 and 4 for ^{60}Co and ^{137}Cs

sources respectively. The exposure unit of all these pen dosimeters is the old one (mR).

The curves obtained from the new pens, with the ^{60}Co source, show that the difference in relation to the use or not of the phantom is smaller compared with the case of old pens. Moreover, all results with the ^{137}Cs source showed higher differences in relation to the use or not of the phantom, for both old and new pens.

The calibration factors of the pen dosimeters were obtained for the ^{60}Co source, and their result intervals are presented in Table 3 with the presence or not of the slab phantom. Of the thirty one pen dosimeters, 80.6% of them presented calibration factors with phantom greater than without phantom; 9.7% presented calibration factors with phantom lower than without phantom; and 9.7% presented the same calibration factors to both cases. Then, most of the pen dosimeters presented different calibration factors depending on the presence of the phantom. The results show the need to calibrate these instruments with phantom.

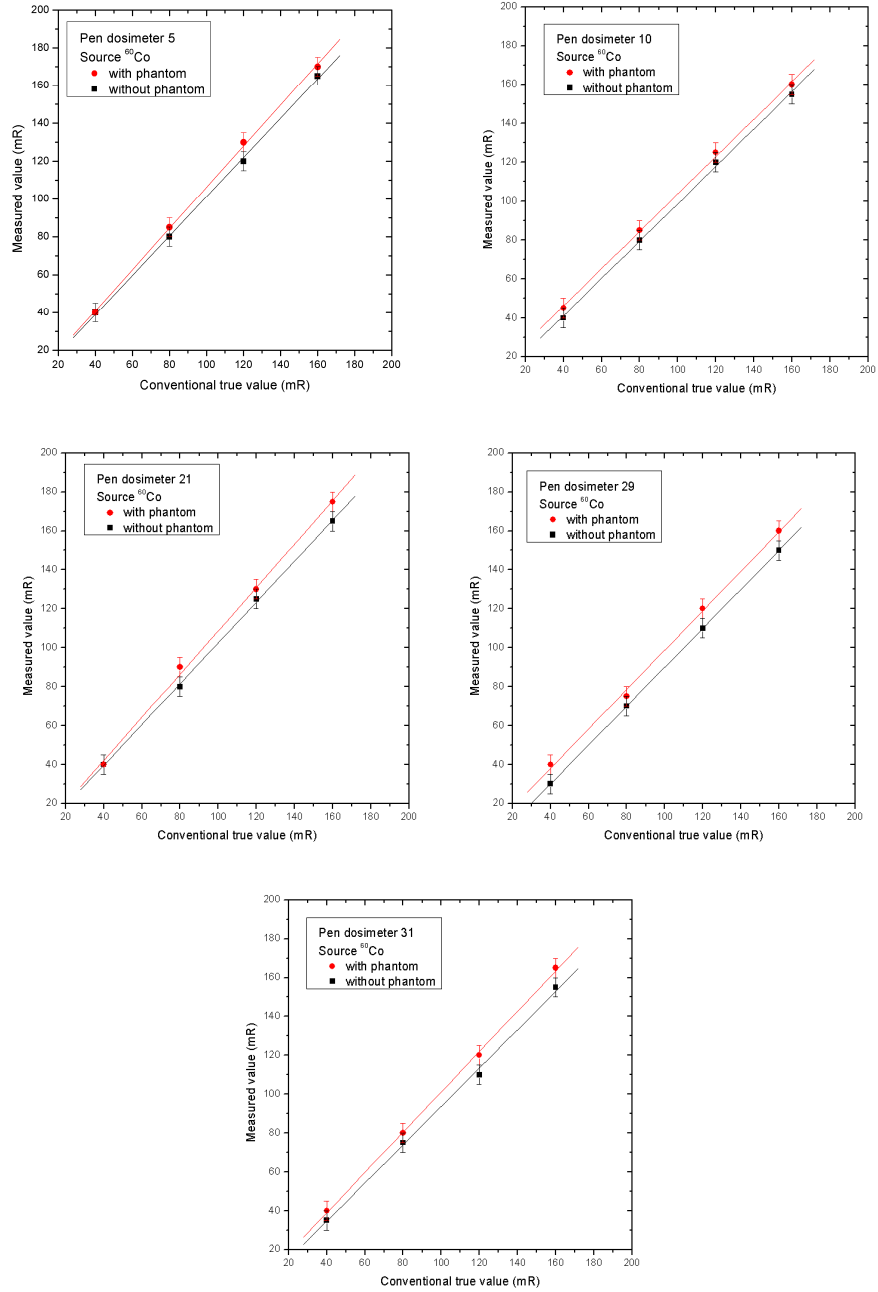


Fig. 3. Dose-response curves of old pens (# 5 and 10) and new pens (# 21, 29 and 31), for ^{60}Co gamma radiation

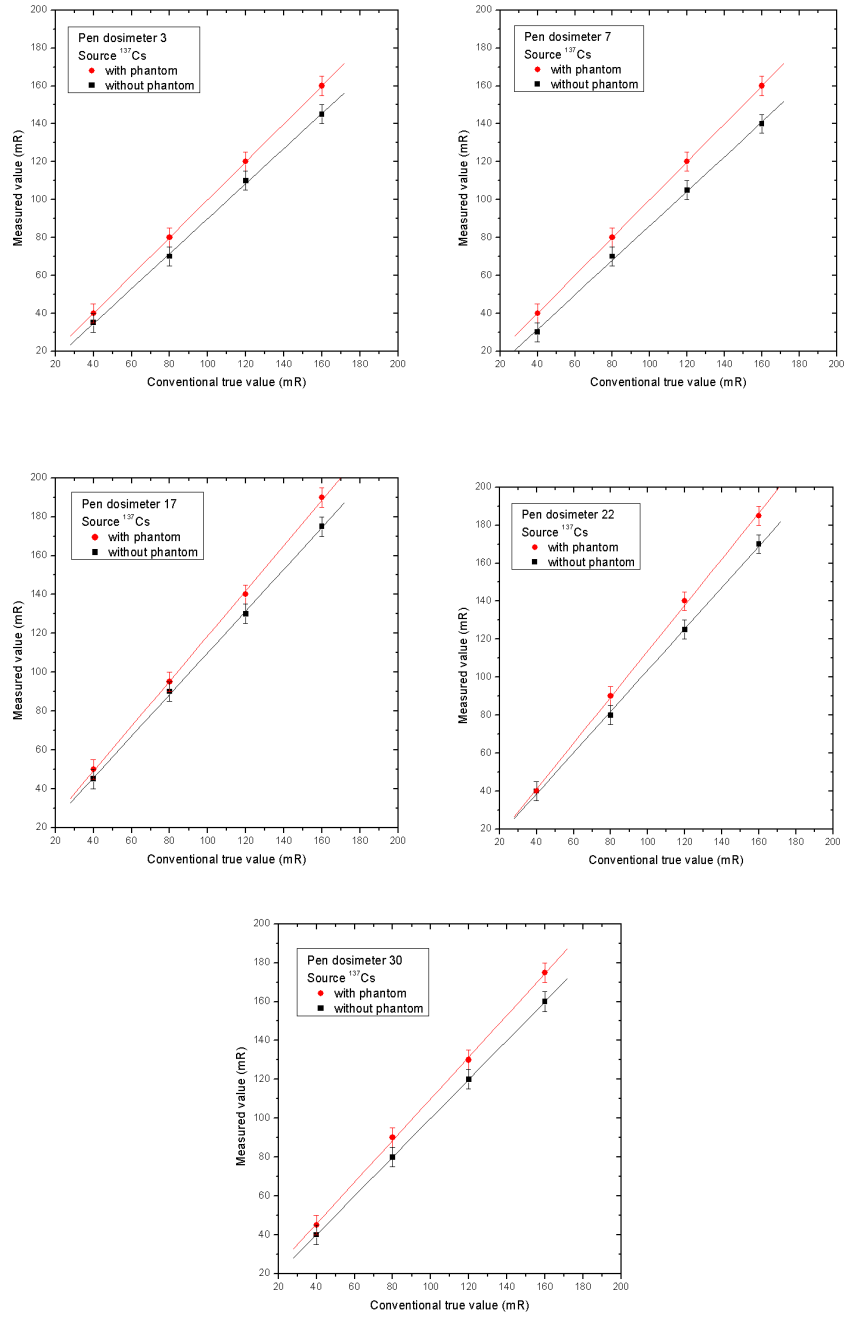


Fig. 4. Dose-response curves of old pens (# 3, 7 and 17) and new pens (# 22 and 30), for ^{137}Cs gamma radiation

Table 3. Interval of calibration factors with (N_1) and without (N_2) phantom, for ^{60}Co radiation.

Pen Code	Variation of calibration factor	
	N_1	N_2
1-6	0.92-1.04	0.97-1.09
7-8	0.96-1.04	1.06-1.09
9-11	0.82-0.96	0.90-0.99
12-13	0.87-1.00	0.85-1.00
14-31	0.89-1.93	0.91-1.11

4 Conclusions

This work presents the dose-response curves of the pen dosimeters for ^{60}Co and ^{137}Cs sources, and with and without the presence of the phantom. The results show differences between them. Therefore, it is necessary to calibrate the pen dosimeters with the phantom, taking into consideration the backscattering. The new pens presented better results than the old pen dosimeters.

Acknowledgments

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