COMPARING THE STABILITY OF TWO IONIZATION CHAMBERS IN STANDARD MAMMOGRAPHY RADIATION BEAMS AND USING AN Sr-90 + Y-90 CHECK DEVICE

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Abstract

Ionization chambers are the recommended devices for the determination of the beam qualities in mammographic range. To assure the reliability of the measurements, the stability of the response of the ionization chamber should be within international limits. The objective of the present paper was to evaluate the stability of response of two ionization chambers. The ionization chambers utilized in this work were a homemade ionization chamber and a reference class ionization chamber. They were irradiated in standard mammography beams and with a $^{90}Sr+^{90}Y$ check device at the Calibration Laboratory of IPEN (LCI). For the short-term stability, the chambers presented a maximum value for the coefficient of variation of 2.9%, within ±3% as stated in the IEC 61674 standard. The long-term stability test results for the ionization chambers were within ±2%, as recommended by the international standard.

1. INTRODUCTION

For the radiation protection of patients during mammography examinations, the radiation dose in the breast tissue should be the minimum necessary to perform an adequate examination image. To accomplish this, the mammographic unit has to follow a quality control program, and an essential part of this program is the radiation beam dosimetry.

Ionization chambers are the most common radiation detectors for dosimetric purposes in diagnostic radiology [1]. They are easy to use and have a simple principle of charge collection. There are many types of ionization chambers but the plane-parallel chamber is the most used one for mammographic quality control and dosimetry [2]. For reliable measurements, the ionization chambers should present stable responses over time. It is important to reduce the errors in the measuring process and to ensure accurate measurements of the beam qualities. The ionization chamber stability response has to be checked periodically [3]. Some authors have reported that this verification is important not only for mammographic beams, but for monitor ionization chambers [4] and diagnostic radiology beams [5] as well.

The objective of the present paper was to study the stability of response of two ionization chambers, one commercial and another homemade, in standard radiation beams and using a $^{90}Sr+^{90}Y$ check device.

2. MATERIALS AND METHODS

In this work, a Pantak Seifert Isovolt 160HS X-ray equipment with tungsten target was used as the irradiation system. This X ray generator operates from 5 to 160 kV and the tube electric current from 1 to 45 mA. The mammography qualities [6] utilized in this work were established at LCI, and they are described in Table 1. A Sr-90+Y-90 PTW check device (33 MBq, 1994) was utilized to compare the behavour of the ionization chambers in X rays beams with a laboratory check device for high precision dosimetry.

TABLE I. PTB MAMMOGRAPHY RADIATION QUALITIES ESTABLISHED AT LCI, WITH MOLYBDENUM AND ALUMINUM ADDITIONAL FILTRATIONS.

Radiation quality	Tube voltage (kV)	Tube current (mA)	Additional filtration mm Al	Additional filtration mm Mo	Half-value layer (mmAl)	Air-kerma rate (mGy/min)
Direct beams						
WMV 28	28	10	---	0.07	0.37	11.94
WMV 30	30	10	---	0.07	0.38	13.48
Attenuated beams						
WMH 28	28	10	2.00	0.07	0.61	0.66
WMH 30	30	10	2.00	0.07	0.68	0.83

The ionization chambers utilized in this work were a tandem ionization chamber [5] and a Radcal RC6M reference ionization chamber. The homemade ionization chamber was developed at LCI, and it consists of two ionization chambers of the same geometry, but with collecting electrodes of different materials: aluminum and graphite. They were manufactured together in the same Lucite body, as a double ionization chamber, and each ionization chamber has a sensitive volume of 6.0 cm^3.

This kind of homemade ionization chamber has the advantage of allowing the routine verification of the effective energies of X radiation beams after an adequate calibration [5]. The Radcal RC6M reference ionization chamber was calibrated at Physikalisch-Technische Bundesanstalt (PTB), and it is the reference system for the LCI mammography qualities.

Two electrometers were utilized in this work: a PTW UNIDOS-E and a Keithley 6517A. The first one was utilized for the measurements of the homemade ionization chamber system, which was polarized with +300 V. The Keithley electrometer was utilized with the Radcal RC6M reference ionization chamber, and a +200 V electric potential was applied to the chamber.

The ionization chambers were positioned at the calibration distance of 100 cm from the X ray focal spot, and all measurements were corrected for the standard environmental conditions of temperature and pressure. The ambient temperature and pressure in the X ray laboratory were monitored by a Hart Scientific thermometer, 1529 model, and a GE Druck barometer, DPI 142 model. The relative humidity varied between 50% and 60%, and it was controlled using dehumidifiers and an air-conditioning system.

3. RESULTS

The stability of the chambers was evaluated by the repeatability test (short-term stability test) and reproducibility test (long-term stability test). For the repeatability test, ten consecutive measurements were obtained and the mean values were calculated. The result for this test is presented in terms of coefficient of variation that is the standard deviation of the readings expressed as a percentage of the mean value of these readings [3]. These results are presented in Table 2. The homemade ionization chamber was named in Table 2 depending on its collecting electrode material.

TABLE II. REPEATABILITY TEST OF THE IONIZATION CHAMBERS.

Radiation quality	Maximum coefficient of variation (%) — Homemade chamber: Aluminum collecting electrode	Homemade chamber: Graphite collecting electrode	Reference chamber: Radcal RC6M
WMV 28	0.09	0.26	0.12
WMV 30	0.11	0.18	0.12
WMH 28	1.62	2.87	1.83
WMH 30	0.89	1.98	1.78
Sr-90+Y-90	0.05	0.02	0.66 *

* Reference [7]

As stated in the IEC 61674 standard [3], the coefficient of variation of ionization chambers for mammography energy range should be within ±3 %. Table 2 shows results within this limit: both ionization chambers followed the international recommendations.

For the reproducibility test, the readings obtained for the repeatability tests were utilized. The tests were undertaken each month over a period of nine months. The mean values from a series of ten repeatability tests were evaluated for the different radiation qualities, and they are presented in Figures 3 to 5. The recommended limits of response variation in this kind of test are ±2 % [3]; the dotted lines in the figures represent these limits. As seen in Figures 3 to 5, the ionization chambers utilized in this work presented a long-term stability within the limits stated in the international standard. The maximum variations were presented by the attenuated beams, as shown by the error bars of Figure 4. This fact is due to the lower air kerma rates in the attenuated beams in relation to those in the direct beams. The long-term stability of the reference ionization chamber used in this work using the Sr-90+Y-90 check device was 1.9 % and therefore also within the limit of ±2 % [7].

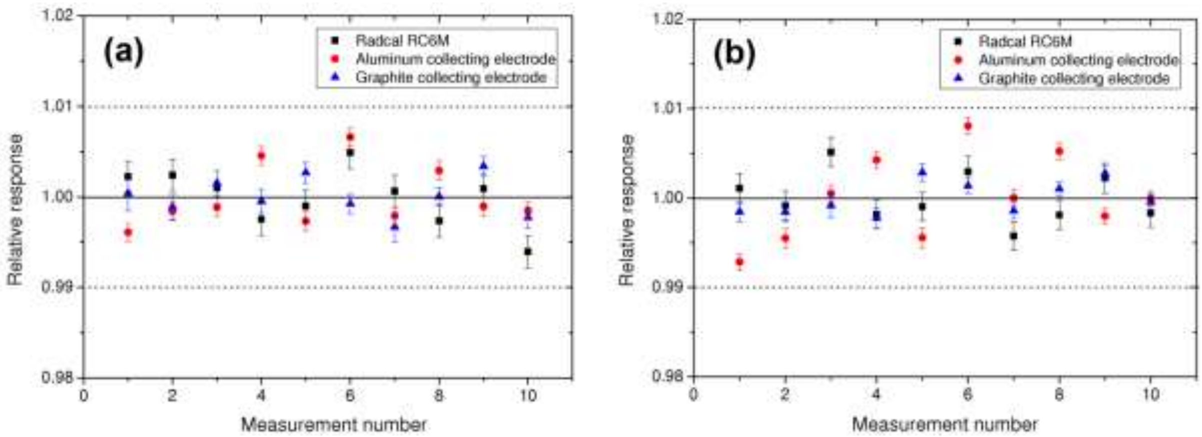

FIG. 3 . Long-term stability test of the Radcal RC6M and homemade (with collecting electrodes of aluminum and graphite) ionization chambers, using the WMV 28 (a) and the WMV 30 (b) radiation qualities. The dotted lines represent the limits of the IEC 61674 standard [3]

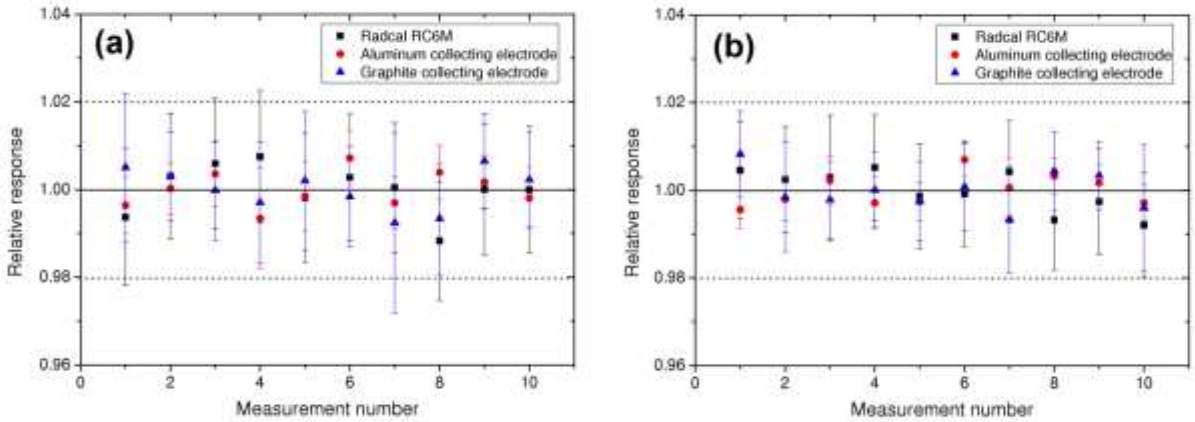

FIG. 4. Long-term stability test of the Radcal RC6M and homemade (with collecting electrodes of aluminum and graphite) ionization chambers, using the WMH 28 (a) and the WMH 30 (b) radiation qualities. The dotted lines represent the limits of the IEC 61674 standard [3]

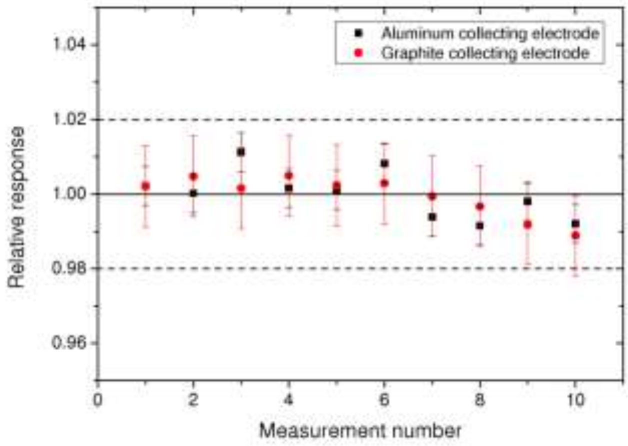

FIG 5. Long-term stability test of the homemade ionization chamber, using the Sr-90+Y-90 check device. The dotted lines represent the limits of the IEC 61674 standard [3]

4. CONCLUSIONS

In this work, the stability of two ionization chambers in standard mammography beams and using a Sr-90+Y-90 check device was evaluated. The maximum variation for the repeatability test (short-term stability) was 2.9% for the homemade ionization chamber with the graphite collecting electrode in the standard WMH 28 beam. All ionization chambers presented long-term stability test results within the limits stated in the IEC 61674 standard [3].

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