Establishment of the new IEC 61267 mammography qualities in a clinical system used for instruments calibration

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Abstract

The mammography is a clinical exam that allows the premature breast cancer, because it is capable to show a possible tumor in its initial stage. But, in order to obtain a reliable diagnosis is necessary that the mammography system be calibrated and working properly, otherwise it can cause a loss in the produced image, which can generate a false result, and a possible damage to the patient. Therefore it is important the quality control of these equipments, especially in terms of the radiation emitted by them. In this study were established the new IEC 61267 mammography qualities in a clinical system. The objective here is to establish a calibration condition that is as close as possible to the hospitals and medical clinics situation, including the scattered radiation from the breast support, the anode effect, the system geometry etc. For this the qualities were established in a VMI mammography system, Graph Mammo AF, which works in a range from 20 kV to 35 kV, has a molybdenum (Mo) target and filtration of Mo and rhodium (Rh). The half-value layers (HVL) used were those presented by the German Primary Dosimetry Laboratory Physikalisch-Technische Bundesanstalt (PTB). Although, the only established qualities were those that use Mo as additional filtration, because the reference ionizing chamber was calibrated only in this condition. To determine if the Mo filtration is appropriate for each quality it is necessary to use the HVL, which must reduce the beam intensity in (50.0 ± 1.5) %. To finish the quality establishment, is necessary to determine the air-kerma rate, which is made using the calibration factor given by the PTB. With this value determined the quality beam used for instruments calibration in mammography is established.

Keywords: Mammography, instruments calibration, quality control, diagnostic radiology

1 Introduction

The Laboratório de Calibração de Instrumentos (LCI) at the Instituto de Pesquisas Energéticas e Nucleares (IPEN) calibrated, during the years 2009 and 2010, about 40 ionizing chambers for mammography. This value represents about 80 % of these chambers present in Brazil[1].

Currently, the LCI has only one system that is used to calibrate these chambers; a Pantak Seifert X-ray system, with tungsten anode and additional filtration of aluminum and molybdenum. These qualities were established using as reference the qualities in use at the German Primary Dosimetry Laboratory Physikalisch-Technische Bundesanstalt (PTB)[2], and following the recommendations the International Eletrotechnical Commission (IEC) standard,

the IEC 61267[3] and the Technical Report Series 457 (TRS-457), by the International Atomic Energy Agency (IAEA)[4].
However, this system does not have a molybdenum anode as a clinical mammography system and because of that it was made a study to establish the mammography calibration qualities in a clinical mammography system, in order to reach calibration conditions as close as possible to the quality control procedures used in hospitals and medical clinics.

2 Materials and Methods

The mammography qualities were established in a VMI mammography system, Graph Mammo AF, which works in a range from 20 kV to 35 kV, has a molybdenum target and filtration of molybdenum and rhodium (Figure 1).

Figure 1. Mammography system used in this study

The first step was to determine the maximum peak voltage (kVp max) and Practical Peak Voltage (PPV). For this it was used a non-invasive kVp meter PTW, Diavolt model, that was positioned on the breast support, according to the figure 2.

Figure 2. The kVp meter (Diavolt) positioned on the breast support

The next step was to determine the half-value layers (HVL), in order to verify if the additional filtration presented in this system is adequate. The instrument used was a Radcal ionizing chamber, RC6M model, for mammography (figure 3).

Figure 3. Radcal Ionizing chamber used to test the HVL

According to the IEC 61267[3] and the TRS-457[4], the HVL must be the same for a given beam quality in any system that the quality is to be established. The additional filtration for a certain system, in a specific beam quality must be determined considering the HVL. As reference it was used the HVL presented by the IEC 61267[3].

According to the international recommendations[3,4] the additional filtration plus the HVL must reduce the beam intensity in (50.0 ± 1.5) %, so the quality can be established. If not, the additional filtration must be changed.

In this case the additional filtration is fixed (0.035 mm of molybdenum). If the reduction falls out of this range the calibration quality cannot be established.

3 Results and Discussion

The results for the PPV measurement are presented in table 1.

Table 1. Mammography system kVp and PPV values obtained with the non-invasive kVp meter

Nominal Voltage (kV)	**kVp maximum (kV)**	**PPV (kV)**
25	25.7 ± 1.0	25.2 ± 1.0
28	28.4 ± 1.1	28.1 ± 1.1
30	30.5 ± 1.2	30.2 ± 1.2
35	35.8 ± 1.4	35.5 ± 1.4

The uncertainties in table 1 were calculated using the type A and type B uncertainties, such as the standard deviation, the Diavolt calibration and display uncertainty.

The values in table 1 show that the mammography system is well calibrated in terms of the tube voltage. The variation between the nominal voltage and the measured kVp max was less than 2.5 %, and the PPV variation was less than 1.5 %.

The test with the HVL was made to verify the additional filtration. The results are shown in table 2.

Table 2. Beam intensity reduction obtained after the HVL insertion.

Nominal voltage (kV)	**Additional Filtration (mmMo)**	**HVL PTB (mmAl)**	**Reduction (%)**
25	0.035	0.29	50.7 ± 0.9
28	0.035	0.32	50.9 ± 0.8
30	0.035	0.33	52.5 ± 0.8
35	0.035	0.37	51.1 ± 0.7

The values presented in table 2 show that the 30 kV beam intensity reduction is out of the range presented by the IEC 61267[3] and the TRS-457[4]. If it were possible to change the additional filtration, than it should be changed and tested until the beam intensity reduction reached the range presented by the standards.

Since it is not possible to change the filtration, the 30 kV quality beam could not be established in this system.

For the others, the next step is to determine the air-kerma rate, $\dot{K}_{air}$, using the equation below:

$$\dot{K}_{air} = M \text{ x } F_{t,p} \text{ x } N_k \text{ x } k_Q \quad (1)$$

where M is the rate of charges collected by the chamber, $F_{t,p}$ is the corrector factor for temperature and pressure, N_k is the chamber calibration coefficient and k_Q is the correction factor for the radiation quality Q. Both N_k and k_Q were given by the primary laboratory where the chamber was calibrated.

In the table 3 are shown the air-kerma rates results for each radiation quality, for 80 mA of tube current and a distance of 60 cm.

Table 3. Air-kerma rate obtained for each mammography radiation quality

Quality	Nominal voltage (kV)	Additional filtration (mmMo)	k_Q	Air-kerma rate (mGy/min)	Air-kerma rate - PTB 1 m, 10 mA (mGy/min)
MMV 25	25	0.035	1.000	3.87E+02	18.0
MMV 28	28	0.035	1.000	5.51E+02	24.6
MMV 35	35	0.035	1.000	1.02E+03	44.4

The air-kerma rates obtained here will be used as reference to calibrate other mammography ionizing chambers. Correcting these values for 10 mA and distance of 1.0 m it is possible to verify how close they are to those presented by the PTB, the German laboratory where the chamber was calibrated.

The nomenclature MMV indicates a quality established in an X-ray system with anode and additional filtration of molybdenum (the letters MM). The letter V indicates an incident beam, and the number refers to the tube voltage.

3 Conclusions

The results show that the system is able to calibrate mammography ionizing chambers in the radiation qualities that use 25 kV, 28 kV and 30 kV.

The quality relative to a tube voltage of 30 kV could not be established, due to the fact that the beam intensity reduction, after the insertion of the HVL, was of 52.5 %. It is important to remember that in this system is not possible to change the additional filtration.

The air-kerma rates were determined, allowing the calibration of the ionization chambers that are used for the quality control of the mammography systems.

This work will be continued with the establishment of the radiation qualities based on a phantom made up of an aluminum added filter, and tests with a PMMA phantom.

Unfortunately it was not possible to study the calibration procedure using the AEC, because this system was not working on this mammography system. We hope to make this in a next study.

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