Sensitometric Analyses of Screen-Film Systems for Mammography Exams in Brazil

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Abstract: The quality control of the automatic film processor was carried out to ensure high level of efficiency. Based on ISO 9236-3, the following potential were applied on the X-rays tube 25 kV, 28 kV, 30 kV and 35kV. Four different mammography films from different manufactures with and without screens were tested for curve shape, speed and average gradient. The results showed that the film 1 has better contrast; the film 3 has the highest energy dependence; the largest base+fog density was presented by film 4. None of the four mammographic films tested achieved satisfactory results in all parameters analyzed.

Keywords: Sensitometric, mammographic, films and manufactures.

1. INTRODUCTION

The image quality of a mammography is the main goal to be achieved by a service that uses radiological films. To obtain an image useful to diagnosis, it is necessary to control the radiological equipment in order to ensure that its operating conditions are in accordance with the manufacturer's recommendations.

Therefore, it is highlighted the importance and efficiency of quality assurance programs (QAP) which refer to the performance of X-ray equipment, processors and screen-film combinations.

The sensitometric parameters assessed in this study are: characteristic curve, average gradient, speed and base+fog of the film-screen system used in mammography exams. The tests were conducted, in part, as recommended by the International Organization for Standardization (ISO 9236-3 1999).

2. MATERIALS AND METHODS

The following equipment were used to carry out the work: x-ray tube (Philips, model PW 2185/00), ionization chamber (Radcal, 10 x 5-6 m model), electrometer (Keithley, 6517A model), aluminum plates (purity of 99.9% and variables thickness from 0.1 mm to 2.0 mm, GoodFellow); intensifying screens (IBF R300MM) , measuring tape, mammography films of different manufacturers, developer and fixer (Kodak), stopwatch (accuracy of ± 0.1 s, MJ-1822-Moure Jar), digital thermometer (Digi-Sense Scanning Thermometer), pHmeter (accuracy 0,1 pH, model PH-107), thiosulfate retention kit, Hypo Kodak, densitometer (Densix,model 603, PTW) Sensitometer (Sensix model 4071 PTW), Automatic Processing (Mamoray Classic, model 1754, AGFA).Four different mammography films (assigned numbers 1, 2, 3 and 4) from different manufactures were tested and evaluated.

The experimental setup to obtain the characteristic curves and the sensitometric parameters is illustrated in figure 1. The optical densities were obtained by positioning a fixed collimator and additional filtering in relation to the focal point of the tube. After it the ionization chamber was fixed, as well the film or the film with cassette, at a fixed distance of 100 cm from the focal point. For exposure without screen, the films were placed inside black plastic bag and sealed, to prevent light inside it. After the film was positioned, using a height-adjustable support. Between the film and the X-ray tube was placed lead plate that has been aligned with the window of the tube using a laser. Also two sheets, one of 1.8 mm Al and another of 0.03 mm Mo in thickness were fixed the filter wheel.

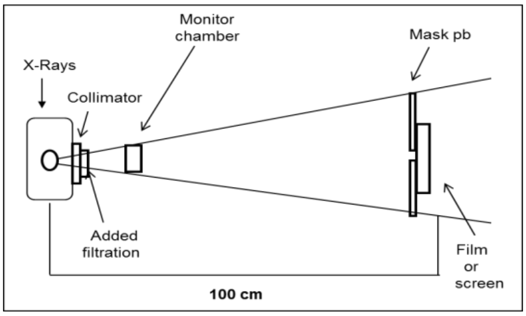

Figure 1- Experimental arrangement used by LCR to obtain the characteristic curve.

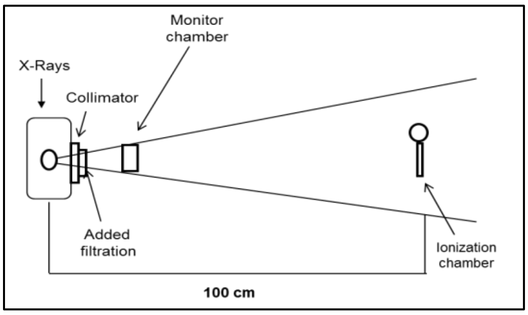

Figure 2- LCR experimental setup to obtain air kerma.

To obtain the kerma corresponding to each optical density, the ionization chamber was placed in the same location before occupied by films during the exposures, i.e. 100 cm (distance between the film and the focal point. Figure 2 shows the experimental arrangement used for obtaining the kerma. To calculate the average gradient and the sensitivity of the film tested, the equations 1 and 2 were used.

$$\overline{G} = \frac{D_2 - D_1}{\log_{10} K_2 - \log_{10} K_1} \qquad (1)$$

$$S = \frac{K_0}{K_S} \qquad (2)$$

where:

D_1 and D_2 are densities whose values are between 2.0 and 0.25 respectively.

K_1 and K_2 are the corresponding values obtained from sensitometric kerma curve.

$K_0 = 10^{-3}$ Gy;

K_0 is the kerma whose optical density is closest to 1.

3. RESULTS

Table 1 presents the beam qualities used to obtain the sensitometric curves, with and without screen (Pires et al 2010), (ISO 9236-3 1999). Figures 3, plots the characteristic curves of the four films for the beam quality of 28 kV presented in Table 1, with screen (Magalhães et al, 2013).

Table 1. Beam qualities for the determination of the sensitometric curve, with and without screen (according TRS 457).

Beam qualities	X-ray tube voltage (kV)	Added filtration (mmMo + mmAl)	HVL (mmAl)
I	25	0,03 +1,8	0,56
II	28	0,03 +1,8	0,61
III	30	0,03 +1,8	0,63
IV	35	0,03 +1,8	0,70

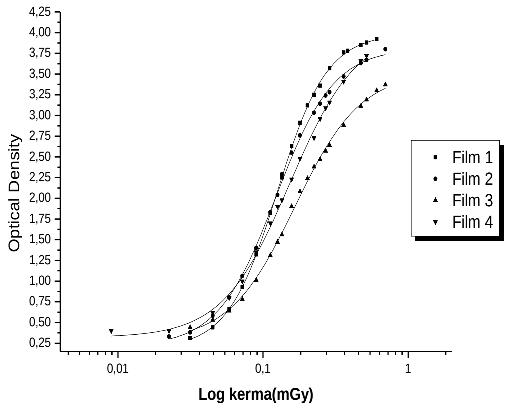

Figure 3 - Overlapping of the characteristic curves for films of the four different manufacturers using same screen at beam quality II.

The characteristic curve of the film 3 presented different behavior for all beam qualities presented compared to the other curves. This shows that the film 3 has higher energy dependency, causing instability which can generate changes of contrast in the image. With greater latitude (higher grayscale), the film 3 can make it difficult to visualize small structures thus creating prejudice to the diagnosis.The characteristic curve of film 1 showed more inclined to the axis of the densities (lower latitude), i.e. a bigger contrast when compared to other films. This characterizes it as a film of better contrast, being able to provide a better image in mammography exams. The film 4 curve shows that density base+fog for all beam qualities is higher. This means that this film also presents a problem in your average gradient, making the useful diagnostic region is impaired. The energy dependency of the films from the four different manufacturers, showed in Figure 4, was determined for an air kerma of 1 mGy correlating the optical densities for this kerma with half-value layers for each potential presented in Table1. The HVL for energetic dependence analysis were obtained based on a published paper (Pires et al, 2010). The film 1, as already noted in the analysis of the sensitometric curves, presents greater stability with changes in beam qualities. So it is a more reliable for the development of diagnostics by present small variations of contrast and sensitivity. Observing the HVL for the potential of 30 kV, noted that the film of greater energy dependence is the film 3. Thus, this is the film of greater instability and may, for example, introduce significant variations of speed at each potential change causing blurring and consequently produce loss for the resolution of the image.

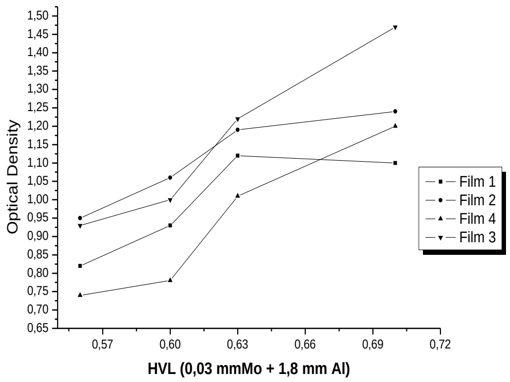

Figure 4 – The energy dependency of the films from four manufactures for ISO qualities at an air kerma of 1 mGy.

The gradient (or radiographic contrast) of the film has limit of ± 0.06. Most films have gradient deviations above the recommended by ISO 9236-3 , as shown in Figure 6.

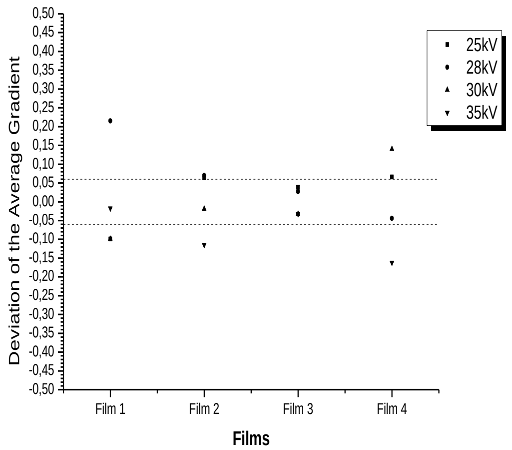

Figure 6 – Plot of the medium gradient for the four films from different manufactures using the beam quality of ISO.

4. Conclusions

In this work was possible to evaluate the important sensitometric parameters characterize four mammography film from different manufactures that are used in Brazil. None of the four mammographic films tested achieved satisfactory results in all parameters analyzed. The film 1 presented the best result, by being the most stable to potential changes, i.e. the emulsion of the film features minor variations of contrast and sensitivity. The calculation of the speed deviation showed that the film 1 was the only one that had results inside acceptable limits for all potential applied what guaranteeing less image blurring. With respect to the calculation of the gradient deviation all films presented results off limits recommended by ISO (ISO 9236-3, 1999). This indicates the need to carry out a more effective quality control at the manufacturing process of mammography films.

5. References

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