

DETERMINATION OF THE TUBE VOLTAGE FROM CLINIC MAMMOGRAPHIC SYSTEM USING TWO TYPES OF DETECTORS

J. S. Barreira¹, V. Vivolo¹

¹Instituto de Pesquisas Energéticas e Nucleares (IPEN)
Comissão Nacional de Energia Nuclear (CNEN)
Av. Lineu Prestes, n° 2242 – Cidade Universitária
05508-000 São Paulo – SP – Brasil
jacsales@usp.br

ABSTRACT

The use of X rays for diagnostic radiology is very common and important to Medicine, including mammographic diagnosis focusing decreasing of the doses applied to the patients and preserving high quality of the diagnostic image. A quality control program of the irradiation systems it is necessary to control periodically the performance of the X-ray systems applied in that diagnosis in order to obtain the best results in that diagnosis. The verification of the beam characteristics is made by using standard dosimetric procedures which include the determination of the kilovoltage and the kerma rates for the different radiation qualities applied in the diagnosis. The Instruments Calibration Laboratory (LCI) of IPEN perform calibration in dosimeters used in radiation dosimetry (in diagnostic radiology) for many years and are improving their methodology to attend the actual demand of that equipments used in quality control of that X-radiation systems. The objective of that paper were the measurements of kVp and air kerma produced for one mammographic system of LCI, Model VMI – Graphmammo AF (Philips) using two different measurements systems from PTW (Diavolt) and Radcal (kVp meter) that procedure is just to determine the stability of that system that is used to perform diagnosis in mammography level. The results obtained with the two systems utilized shows good agreement. That measurement can be applied at a routine quality control program of that X-ray system.

1. INTRODUCTION

Breast cancer accounts for nearly 25% of all cases and is the most common type among women in the world. Estimates for 2014 indicate 57,000 new cases of breast cancer in Brazil, the third highest incidence, behind melanoma and prostate cancer.

The World Health Organization (WHO) estimates 27 million new cancer cases for 2030 worldwide, and 17 million deaths from the disease. Developing countries will be most affected, including Brazil. [1]

Given this scenario, it becomes essential mammography in screening and detection of breast cancer. But to obtain a suitable image, it is necessary that the X-ray emitter equipment is properly calibrated.

The objective of that paper were the measurements of kVp and air kerma produced for one mammographic system of LCI, Model VMI – Graphmammo AF (Philips) using two different measurements systems from PTW (Diavolt) and Radcal (kVp meter) that procedure is just to determine the stability of that system that is used to perform diagnosis in mammography level. That measurement can be applied at a routine quality control program of that X-ray system.

2. MATERIALS AND METHODS

In this study were used the VMI Graph Mammo AF Phillips (Figure 1), who operates in the range 20 to 35 kilovolts (kV), has target of Molybdenum (Mo) and inherent filter Rhodium (Rh) and Molybdenum.



Figure 1: VMI Graph Mammo AF Phillips

To perform the measurements, were used PTW Universal All-in-one QC Meter T43014 (non-invasive meter) shown in Figure 2. This machine performs multiple measurements in a single exposure, like the dose in mGy, the time of exposure in ms, the PPV (Practical Peak Voltage) and the mean kVp and the maximum kVp.



Figure 2: PTW Universal All-in-one QC Meter T43014

For reproducibility test of the tube voltage, were used the Accu meter Radcal kV model 4082 coupled to the sensor with high sensitivity Radcal Accu kV 22-40 kV, Model 40x5 – Mo. The equipment was kindly provided by Physics Institute (São Paulo University), shown in Figure 3:



Figure 3: Accu meter Radcal KV model 4082 coupled to the sensor Radcal Accu KV 22-40 KV, Model 40x5 - Mo

Tension (kV) used in typical mammography beams intervals were selected: 25, 28, 30 and 35 kV. The objective was to verify if the measured kV was in agreement with the nominal kV mammography and its reproducibility.

The meter (Radcal Accu kV or PTW Diavolt) was positioned in the center of the sensor support breast, 4 cm from the edge thereof, and third exposures with intervals of each voltage (kV) for mammography mentioned above were performed.

The values obtained were compared to verify the reproducibility of measurements/exhibitions. Then, the average value of the three was calculated and displays the obtained value was compared with the nominal kV for obtaining accurately the tube voltage.

For determination of the dose, were conducted measurements with 28 kV and mAs varied, with PTW Diavolt, centered at the point of incidence radioactive beam. The meter Radcal Accu kV measure only tension, not dose, thus no comparison between the results of two equipments.

The PPV greatness is relatively new and is related to image quality in radiological examinations. She first appeared in 2005 (IEC 61267), and since then its measurement became necessary before deploying X radiation qualities in a calibration system of dosimetric instruments.

For this measurement, we used the radiation beam with Mo filter as Diavolt does not perform the readings for the target combination filter Mo and Rh.

3. RESULTS

Table 1 shows the results obtained for the reproducibility of tube voltage with Radcal Accu kV:

Nominal Tension (kV)	Variation
25	$\pm 0,02\%$
28	$\pm 0,02\%$
30	$\pm 0,01\%$
35	$\pm 0,01\%$

Table 1: reproducibility test of the tube voltage with the intervals of the mammography use Radcal Accu KV.

Table 2 shows the results obtained for the reproducibility of tube voltage with PTW Diavolt:

Nominal Tension (kV)	Variation
25	$\pm 0,04\%$
28	$\pm 0,02\%$
30	0
35	0

Table 2: reproducibility test of the tube voltage with the intervals of the mammography use PTW Diavolt.

The PTW Diavolt acquired the best reproducibility in 30 and 35 kV, the same reproducibility than meter Radcal Accu kV for 28 kV. Only in 25 kV, the variation measured with PTW Diavolt is larger than variation acquired by Radcal Accu kV.

It can be seen that the reproducibility is within the IEC 61676 standard [2], IAEA / ARCAL XLIX [3], where the variation between measurements on the same kV can not be greater than $\pm 2\%$.

Table 3 lists the results that were obtained in the accuracy of the test tube voltage with Radcal Accu kV:

Nominal Tension (kv)	Tension mesured with Radcal Accu kV	Variation
25	24,9	$\pm 0,01\%$
28	28	0
30	29,9	$\pm 0,01$
35	34,7	$\pm 0,08\%$

Table 3: Values obtained in the accuracy test tube voltage

Table 4 lists the results that were obtained in the accuracy of the test tube voltage with PTW Diavolt:

Nominal Tension (kv)	Tension mesured with PTW Diavolt	Variation
25	25,5	$\pm 0,1\%$
28	28,1	$\pm 0,03$
30	30,2	$\pm 0,06$
35	35,5	$\pm 0,1\%$

Table 4: Values obtained in the accuracy test tube voltage

It appears that the accuracy of the tube voltage is in accordance with IEC 61676, IAEA / ARCAL XLIX where the variation between the measured and nominal kV can not be greater than $\pm 5\%$.

In this test, the meter Radcal Accu kV was more specific than PTW Diavolt.

Table 5 presents the maximum average kVp and kVp with PTW Diavolt obtained for each strain selected in mammography. Radcal Accu kV not measured this tensions, so there was no comparison between the results.

Nominal Tension (kv)	Maximum kVp	Mean kVp
25	25,6	25,5
28	28,3	28,1
30	30,3	30,2
35	35,6	35,5

Table 5: Values of maximum and mean kVp in the range of voltage (KV) to mammography, used meter PTW Diavolt

According to ANVISA's 2005 manual [4], the air kerma rate for a given kV and mAs can not vary more than 10% in 4 consecutive exposures.

Current-time Product (mAs)	Kerma (mGy) – mean of 4 consecutive exposures	Variation
20	2,2	±0,9%
50	5,7	±0,2%
100	11,39	±0,1%
200	22,82	0

Table 7: Variation of air kerma at different mAs did not exceed 10%. Result is within the norm of ANVISA (2005)

Table 8 shows the values of PPV found in between mammography and its variation from the nominal kV (accuracy) are:

Nominal kV	Practical Peak Voltage - PPV	Variation
25	25,1	0,02%
28	27,9	0,02 %
30	30	0
35	35,3	0,08%

Table 8: Values of PPV found for the voltage range from mammography and variation between measurements.

The reproducibility of PPV in three exhibitions in each selected kV was full, there was no variation in the measurements, ie, the three exhibitions with 25 kV obtained the PPV of 25.1; 28 kV with the PPV obtained in 3 exposures was 27.9; 30 kV with the PPV was 30 and 35 kV, was 35.3 for the three exhibitions. Thus reproducible readings obtained.

4. CONCLUSIONS

The measurements of kVp and air kerma produced by mammographic system of LCI, Model VMI – Graphmammo AF (Philips) using two different measurements systems from PTW (Diavolt) and Radcal (kVp meter) shows the stability of that system. The results obtained with the two equipments utilized shows good agreement.

That measurement can be applied at a routine quality control program of that X-ray system.

REFERENCES

1. Instituto Nacional Do Câncer (Ministério da Saúde). *Estimativa / 2012 - Incidência de Câncer no Brasil*. Rio de Janeiro, RJ (2011).
2. International Electrotechnical Commission. *Medical electrical equipment – Dosimetric instruments used for non-invasive measurement of X-ray tube voltage in diagnostic radiology*, IEC 61676, Geneva, 2002.
3. IAEA / ARCAL XLIX , *Protocolos de Control de Calidad en Radiodiagnostico*. Acuerdo de Cooperación Regional para la Promoción de la Ciencia Nuclear y Tecnología em América Latina y el Caribe – 2001.
4. Anvisa, Agência Nacional De Vigilância Sanitária. *Radiodiagnóstico Médico: Desempenho de Equipamentos e Segurança*. Brasília: Ministério da Saúde, 2005.