LOW ENERGY X-RAY SYSTEM SPECTROMETRY

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ABSTRACT

The spectra measurements of an X-rays system are very important for the establishment of the calibration qualities and to determine the relation between the nominal and the real tube voltages. Considering that the X radiation system of the Calibration Laboratory of IPEN is being used to calibrate instruments at the radiotherapy, radiation protection and diagnostic radiology levels, the spectrometry of this system is necessary . In this work the spectra measurements of the established X radiation qualities are presented.

I. INTRODUCTION

Since 1980 instruments are being calibrated at the Calibration Laboratory of IPEN at radiotherapy and radiation protection levels. Recently a few qualities at the diagnostic radiology level were established to test some instruments.

At the radiation protection level there are special set-ups with gamma (^{60}Co and ^{137}Cs), beta (^{90}Sr + ^{90}Y, ^{204}Tl and ^{147}Pm) and alpha (^{241}Am, ^{233}U, ^{238}Pu, ^{244}Cm, etc.) radiations. Clinical dosemeters (radiotherapy level) can be calibrated, depending on the model, using gamma (^{60}Co and/or ^{137}Cs) or low energy X radiation. Finally, portable instruments (ionization chambers) used at diagnostic radiology level have been tested in three low energy X radiation qualities.

The X radiation spectra are essential to verify the main characteristics of a radiation quality (tube voltage, effective and medium energies, half value layer) and a good knowledge of the X-rays spectra is important for many applications[1,2,3], whether for diagnostic radiology or dosimetry. Considering that there is a low energy X radiation machine (60 kV) as part of the Calibration Laboratory irradiation systems which is used in the cases quoted above, the objective of this work is to determine the spectrometric characteristics of the already established X radiation qualities.

II. MATERIALS AND METHODS

The X-rays generating system consists of a Rigaku Denki generator, model Geigerflex, coupled to a Philips tube model PW/2184/00 (Tungsten target and Beryllium window). For the maximum tube voltage determination measurements were taken from 20 to 60 kV. Than the spectrometric measurements of the established radiation qualities listed in Tables 1 and 2 were performed.

TABLE 1. Radiation Protection Qualities Established At the Calibration Laboratory of IPEN[4]

Voltage (kV)	Effective Energy (keV)	Additional Filtration mmAl	Additional Filtration mmCu	First HVL mmAl	First HVL mmCu
20	16	0.92		0.35	
25	20	1.7		0.66	
30	24	2.7		1.02	
40	31	4.92		1.95	
40	31	1.83	0.10	0.95	
50	38	1.12	0.23	3.27	
40-ISO	33		0.21		0.09
60-ISO	48		0.57		0.23

TABLE 2. Diagnostic Radiology Qualities Established at the Calibration Laboratory of IPEN[5]

Voltage (kV)	Additional Filtration (mmAl)	Effective Energy (keV)	First HVL (mmAl)
30	2	19.0	0.947
40	4	28.2	1.84
50	10	38.9	3.61

A portable gamma and X ray Intertechnique spectrometer system was used. It consists of a planar hyper pure Germanium (HPGe) Σurisys Mesures detector (16 mm diameter, 13 mm thickness) connected to a 5 litre dewar vessel, spectroscopy amplifier with pile-up rejection, multichannel analyser with ultra fast ADC,

power supply and high voltage supply in a mini rack, and a notebook with the interpc spectrometry software. The spectrometer was calibrated using an ^{241}Am source with emission peaks at 59.537 keV (γ rays) and 17.611 keV (X rays).

III. RESULTS

The maximum tube voltages (kVp) obtained are shown in Fig. 1. The values show an excellent agreement between the nominal and the real tube voltages; the relation between them is related in Table 3; the uncertanties were in all cases less than 1%. It can be realized that the end point energy was always higher than the expected values as indicated by others authors in some cases[3]. In Fig. 2 and 3 the spectra measured for the radiation protection and diagnostic radiology qualities can be observed.

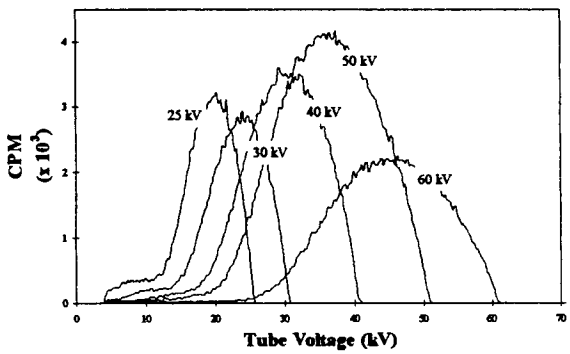

Figure 1. The Maximum Tube Voltages (kVp) Determination from 20 to 60 kV.

TABLE 3. Relation between Real and Nominal Tube Voltages

Real Tube Voltage R_V (kV)	Nominal Tube Voltage N_V (kV)	R_V/N_V
25.7	25	1.03
31.5	30	1.05
41.4	40	1.04
51.8	50	1.04
61.4	60	1.02

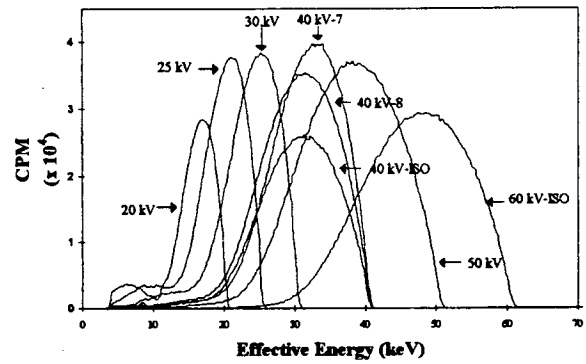

Figure 2. Spectra of Radiation Protection Qualities. 40 kV-7 and 40 kV-8 means 4.92 mmAl and 1.83 mmAl of additional filtration respectively

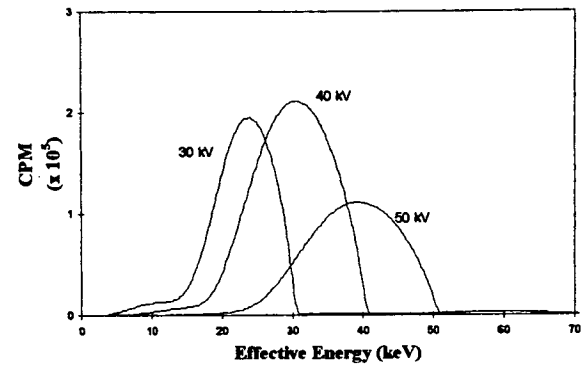

Figure 3. Spectra of Diagnostic Radiology Qualities

IV. CONCLUSIONS

The effective energy and maximum tube voltage values of the low energy x-ray system obtained by spectrometry are in good agreement with the former measurements performed experimentally as shown in Tables 1 and 2. These results show the adequate behavior of this system which is used for instruments' calibration, and they provide a greater confidence in its utilization too.

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