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EVALUATION OF THE CALIBRATION OF INSTRUMENTS IN DIAGNOSTIC RADIOLOGY QUALITIES

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ABSTRACT

This work presents the analyze of the results obtained in the calibration of instruments used in mammography, computed tomography, dental and conventional diagnostic radiology dosimetry, using diagnostic radiology qualities as recommended by the standard IEC 61267 and ISO 4037-1. The instruments normally used for diagnostic radiology measurements are ionization chambers with volumes varying from 3 to 1800 cm^3, and can be cylindrical, spherical or plane parallel plates kind. They usually are sensitive to photon particles, with energies greater than 15 keV and can be used up to 1200 keV. In this work they were tested in X radiation fields from 25 to 150 kV, in specific qualities depending on the utilization of the instrument. The calibration results of 244 instruments received from 2005 to 2006 were analysed. About 20 instruments were not able to be calibrated due to bad functioning. The calibration coefficients obtained were between 0.88 and 1.24.

1. INTRODUCTION

The Calibration Laboratory of Instituto de Pesquisas Energéticas e Nucleares, IPEN, has already over 35 years been calibrating instruments used in radiation protection and therapy measurements that belongs to hospitals, industries, clinics and other users located in São Paulo state and in other parts of Brazil. At the present time, the Calibration Laboratory acts in the Radiation Protection, Radiation Therapy, Nuclear Medicine and Diagnostic Radiology areas, using special set-ups with gamma and beta radiation sealed sources, alpha and beta radiation planar sources and low and intermediate energies of X radiation.

The instruments used in diagnostic radiology measurements represent 8 % of the tested instruments by the laboratory annually (approximately 1600 in 2006). Considering that the calibration of this kind of instrument is performed biannually and only the Calibration Laboratory of IPEN is offering this calibration service in Brazil, it is possible to conclude that almost 300 instruments are being used to measure the air kerma in diagnostic radiology clinics to determine the in beam values (in front of the patient), attenuated measurements (behind the patient) and scattered radiation. They are, in most cases, ionization chambers with volumes varying from 3 to 1800 cm^3, and can be cylindrical, spherical or plane parallel plates kind. They usually are sensitive to photon particles, with energies greater than 15 keV and can be used up to 1200 keV. These instruments are used in mammography, computed tomography, dental and conventional diagnostic radiology dosimetry.

The objective of this work is to present and analyze the results about this kind of calibration using diagnostic radiology qualities as recommended by the standard IEC 61267 [1] and ISO 4037-1[2].

2. MATERIALS AND METHODS

In this work the instruments were tested in X radiation fields from 25 to 150 kV, in specific qualities depending on the utilization of the instrument. The radiation qualities established at the Calibration Laboratory of IPEN are described in Tables 1, 2 and 3 for general diagnostic radiology and computed tomography, for mammography and for radiation protection respectively.

Table 1. Non-attenuated radiation qualities to diagnostic radiology calibration for general and computed tomography applications [3].

Radiation Quality	Total Filtration (mmAl)	Effective Energy (kev)	Tube Voltage (kv)	Half Value Layer (mmAl)	Air Kerma Rate (mGy/min
RQR 3	2.5	27.15	50	1.79	23.21
RQR 5	2.5	30.15	70	2.35	45.96
RQR 7	2.5	33.05	90	2.95	72.91
RQR 9	2.5	37.05	120	3.84	119.88
RQR 10	2.5	40.75	150	4.73	172.81

Table 2. Radiation qualities to radiation protection instruments calibration [4].

Radiation Quality	Total Filtration (mm)	Effective Energy (kev)	Tube Voltage (kv)	Half Value Layer (mmAl)	Air Kerma Rate (Gy/h)
N60	4 Al +0.6 Cu	48	60	0.25	1.99×10^{-2}
N80	4 Al +2 Cu	65	80	0.612	1.05×10^{-2}
N100	4 Al +5 Cu	83	100	1.14	5.01×10^{-3}
N150	4 Al +2.5 Sn	118	150	2.4	4.15×10^{-2}

Table 3. Radiation qualities to mammography calibrations [5]. The x index is related to attenuated beams.

Radiation Quality	Total Filtration (mm)	Effective Energy (kev)	Tube Voltage (kv)	Half Value Layer (mmAl)	Air Kerma Rate (mGy/min
M25	0.06 Mo	15.1	25	0.33	32.9
M28	0.06 Mo	15.3	28	0.34	39.3
M35	0.06 Mo	16.2	35	0.38	59.5
M25x	0.06 Mo + 2 Al	18.8	25	0.58	1.46
M28x	0.06 Mo + 2 Al	19.0	28	0.61	2.02
M35x	0.06 Mo + 2 Al	21.6	35	0.85	4.7

The standard radiation qualities describes at Tables 1 and 2 were established at the X radiation system Seifert, model ISOVOLT 160HS, from 50 to 150 kV. The radiation qualities to mammography calibrations were established at the Rigaku Denki X radiation system, model Geigerflex (60kV), from 25 to 35 kV. These X radiations systems are showed in Fig. 1.

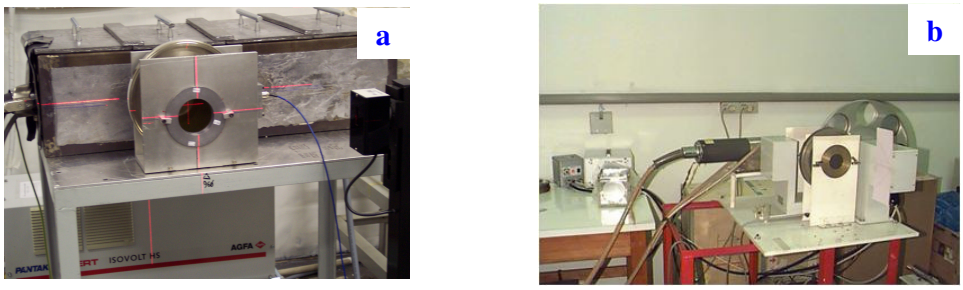

Figure 1. X radiation systems used to instruments calibration used in diagnostic radiology measurements: a) Seifert system b) Rigaku Denki system

3. RESULTS

During the period of 2005 and 2006 it was tested 224 instruments distributed in 13 different manufactures and 42 models, as listed in Table 4. About 20 instruments were not able to be calibrated due to bad functioning. It was received 46 instruments with internal probes and between the external probes instruments it was found 39 different models depending on the application.

Table 4. Instruments tested at the calibration laboratory of IPEN in diagnostic radiology qualities.

Manufacturer	Number of instruments	Types of Models
Cardinal Health	1	1
Eberline	2	1
Gammex	2	2
Inovision	10	2
Morgan	3	1
MRA	1	1
Nardeaux	3	2
Radcal	154	10
Rotem	2	2
RTI	4	3
Step	1	1
Unfors	3	3
Victoreen	38	13

The kind of calibration executed depending on the application of the instrument. The active volume of the probe can vary from 3 to 1800 cm^3. The first thing that was done before the calibration tests was the selection of the appropriate radiation quality for each instrument. Although there are three available series of radiation quality to this kind of calibration (RQR, N and M), the applications can be until 7 and they are described at Table 5. The column 3 shows the adequate radiation qualities for each specific application that were used at Calibration Laboratory of IPEN.

Table 5. Instruments tested at the calibration laboratory of IPEN in diagnostic radiology qualities.

Application	Number of instruments	Active volume (cm^3)	Radiation quality series
General radiology	73	3 to 36	RQR
Computed Tomography	14	3	RQR (100-150kV)
Fluoroscopy	6	60	RQR (50-100 kV)
Mammography	23	6	M
Multi-function (general/fluoro/mammo)	1	51	RQR/M
Radiation protection	59	5 to 1800	N
Radiation protecion and general radiology	48	180	RQR/N

The calibration coefficients obtained were between 0.88 and 1.24. The uncertainties were always less than ± 3.6% to instruments used in scattered radiation measurements (radiation protection); ± 3.0% to mammography instruments; ± 1.6% to computed tomography instruments and ± 1.5% to in beam radiation in conventional diagnostic radiology (RQR).

4. CONCLUSIONS

The results show the importance in the knowledge of the specific characteristics and the correct application of the ionization chambers used in diagnostic radiology measurements avoiding misunderstand related to the adequate series of radiation qualities used in calibration. This study is part of the complete calibration database in development at the calibration laboratory of IPEN.

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