

STUDY OF THE PERFORMANCE OF DIAGNOSTIC RADIOLOGY INSTRUMENTS DURING CALIBRATION

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1. Introduction

Routinely the Laboratory of Calibration of Instrumentos (LCI) carries through, has more than 30 years, calibration of measuring instruments of radiation, that are used in measures of radioproteção, x-ray and, more recently in radiodiagnóstico. This service is given the hospitals, industries, clinics and other users located in all Brazil. The LCI belongs to the Center of Metrologia of the Radiations of the IPEN. In level of Radioproteção composites for sources are used arrangements special radiation standards gamma (^{60}Co and ^{137}Cs), of radiation beta (^{90}Sr + ^{90}Y , ^{204}Tl and ^{147}Pm) and plain sources of extensive area of alpha radiation (^{241}Am) and beta (^{14}C , ^{147}Pm , ^{22}Em , ^{36}Cl , ^{90}Sr and ^{137}Cs).

For the calibration of the clinical dosimeters (level X-ray) the LCI possesss as reference systems secondary standard (chambers of ionization of the type superficial thimble and connected the specific electrometers). As irradiadores it possesss systems of teleterapia of ^{60}Co and ^{137}Cs and a system of radiation X of low energies (60 kV). In the area of Radiodiagnóstico, the LCI possesss a composed system of reference for two chambers of ionization, one for measures of the direct beam and another one for measures of spread beam, electrometers for the connection of the chambers, and two systems of radiation X, being a machine of radiodiagnóstico (125 kV) and a machine of radiation X, continuous beam, acquired recently, with tension applied to 160 the maximum pipe of kV. Moreover, it also possesss, an invasive system (Dinalyzer) and two not invasive systems (NERO and RMI) for quality control of the systems of radiation X.

The 1870 in 2005 are verified approximately that the annually tested equipment number comes increasing systematically, of 170 in 1980. This fact makes with that it is necessary the use of tools capable to facilitate the control of the received instruments, with regard to the information techniques of each one, as well as an analysis of the performance of these instruments in radiation beams.

2. Objectives

The objective of this work is to present and to analyze the results of the instruments sent to the LCI and that they had been calibrated using qualities of radiodiagnóstico recommended by 6127 norms IEC [] and ISO 4037-1[²]

3. Summary of the activities carried through in the previous period

1. Data-collecting on the instruments received for calibration in the LCI in the period of 2005 and 2006: In this period 224 instruments distributed in 13 different manufacturers and 42 models had been tested, as it shows table 1.

Table 1. Instruments tested in the LCI in the qualities of radiodiagnóstico

Fabricate	Number of instruments	Numerous of model
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 type of carried through calibration depended on the application of the instrument. Before any test the appropriate qualities for each instrument had been identified. Although three series of radiation exist, the applications can be of up to seven types and are described in table 2. Column three demonstrates the qualities adjusted for each specific application.

TABLE 2. Instruments tested for type of application.

Application	N° of instruments	Active volume (cm ³)	Quality of the radiation
General radiology	73	3 to 36	RQR
Computed tomografy	14	3	RQR
Fluoroscopy	6	60	RQR
Mammografhy	23	6	M
Multi-fuction (general/fluoro/mammo)	1	51	RQR/M
Radiation protection	59	5 to 1800	N
Radiation protecion and general radiology	48	180	RQR/N

4. Description sucinta of the activities developed in the period

- Continuation of the data-collecting of the tested instruments, including the measures of 2007, totalizing 390 instruments received between 2005 and 2007. It surrounds 20 instruments had not presented calibration conditions. This survey is made in the following way:
 - Act of receiving of the instrument with documents sent by the customer;
 - Identification of the instruments and its (s) respective (s) sounding lead (s);
 - Identification of the type of calibration for each sounding lead;
 - Accompaniment of the tests of calibration until the finishing of the service;
 - Writing of the calibration certificate.
- Evaluation of the results gotten in the calibration of the 390 instruments received in the LCI in this period and calibrated in radiation X: the calibration coefficients are gotten by the reason of the tax of kerma in real air determined with the instrument of reference and the reading of the chamber of ionization in test. The uncertainties gotten for each in case that also they had been considered for the composition of the data base. All the measures had been corrected for the ambient conditions of reference.
- Study of program of data base for use in the present work.

In this work the instruments had been tested in fields of radiation X of 25 the 150 kV, in specific qualities depending on the use of the instrument. The established qualities of the radiation in the LCI are described in

table 3 for radiodiagnóstico and cat scan in general computerized, in table 4 for radiological protection and in table 5 for mamografía.

Table 3. Radiation qualities to radiation protection instruments calibration [1].

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 4. Non-attenuated radiation qualities to diagnostic radiology calibration for general and computed tomography applications.

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 5. Qualities of calibration for mamografía (attenuated and not attenuated beams).

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

The described qualities of radiation in tables 1 and 2 are established in the system of radiation X Seifert ISOVOLT, model 160HS, of 50 the 150 kV. The qualities of radiation for mamografía had been established in the system of radiation X Rigaku Denki, GeigerFlex model (60kV).

The used method of calibration is of the substitution, therefore in each measure, initially it is made measured with the system of reference for determination of the taxes of kerma in air.

4. Results and quarrel.

The gotten coefficients of calibration are related in table 6. The gotten coefficients of calibration esiveram between 0,906 and 1,35. The uncertainties had been between + 3.6% for the instruments used in measures of spread radiation (qualities of radiation N (2)); + 3.0% for the instruments used in mamografia; + 1.6% for the used ones in computerized cat scan e + 1.5% for the used ones in measures of direct beam in conventional radiodiagnóstico.

Table 6. Coefficients of calibration gotten in the period of 2005 the 2007, for the instruments calibrated in feixes of radiation X

Instrument/Application	Coefficient of Calibration		Quality of the radiation
	Mínimum	Máximum	
General radiology	0,906	1,13	RQR
Computed Tomography	1,07	1,18	RQR
Fluoroscopy	0,906	1,13	RQR
Mammography	1,05	1,098	M
Multi-function (general/fluoro/mammo)	0,906	1,13	RQR/M
Radiation protection	1,05	1,35	N
Radiation protection end general radiology	0,919	1,11	RQR/N

5. Conclusion

The results show to the importance in the knowledge of the specific characteristics and the correct application of the used chambers of ionization in measures of radiodiagnóstico preventing errors related to the series of adjusted qualities of radiation for the calibration. This study it is part of the data base of the calibration in development in the laboratory of calibration of the IPEN.

6. Bibliographical reference.

1. International Electrotechnical Commission. Medical diagnostic X-ray equipment – Radiations conditions for use in the determination of characteristics, Standard IEC 61267, Geneva (1994).
2. International Organization for Standardization. X and gamma reference radiation for calibrating dosimeters and doserate meters and for determining their response as a function of photon energy -- Part 1: Radiation characteristics and production methods, ISO 4037-1, Geneva (1996).