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DETERMINATION OF INHERENT AND ADDITIONAL FILTRATION IN ORDER TO ESTABLISH RADIATION QUALITIES ACCORDING TO IEC 61267

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ABSTRACT

In order to establish the radiation qualities recommended do the IEC 61267 to diagnostic radiology calibration, it was determined the inherent and additional filtration of an X rays system at the Calibration Laboratory of IPEN. To determine the inherent filtration it was used the methodology recommended by the norm ISO 4037-1. The HVL found was 0.1 mmAl. After that, using the published data at the ISO 4037-1, it was calculated the inherent filtration correspondent to this HVL, by extrapolation method. The inherent filtration found was 0.138 mmAl. To determine the additional filtration necessary to get each one of the RQR radiation qualities, according to IEC 61267, it is necessary to make an attenuation curve with no filtration. After that a transparent rectangle template representing the first and the second HVL, correspondent to the specific RQR, was made and it was slid through the curve. When the edges of the rectangle fit the curve, it is found the additional filtration to the specific radiation quality. This procedure was applied to each radiation quality from 40 to 150 kV. According to the IEC 61267, after the additional filtration determination, the correspondent HVL must be added and the relation between the values obtained with and without this HVL must be from 0.485 and 0.515. In this work all obtained values were inside this range, nevertheless, a fine adjustment was made in order to get a relation of 0.500. The obtained additional filtration to the RQR qualities was from 2.3 mmAl to 4.2 mmAl.

1. INTRODUCTION

The International Electrotechnical Commission (IEC) is a global organization that prepares and publishes international standards for all questions applied to the electric field and related technologies. Its publication IEC 61267[1] in conjunction with the publication 4037-1 of the International Organization for Standardization (ISO)[2] lays down specific conditions for the characterization of X radiation beams used to test and calibrate instruments. Its first edition published in 1994 was technically reviewed in 2005 and the main changes included in this second edition were:

- Introduction of the quantity "Practical Peak Voltage" (PPV) to measure the voltage of the X-ray tube;
- Determination of an additional filtration for each radiation quality.

The International Atomic Energy Agency published, in 2007, a code of practice for dosimetry in diagnostic radiology which can be used by dosimetry laboratories as well as by the diagnostic radiology services. Such document provides procedures to establish specific diagnostic radiology radiation qualities in order to calibrate instruments and to use these calibrated instruments to perform dosimetric procedures in clinical practices [3]. This document recommends the use of all radiation qualities as described in the IEC 61267[1].

The objective of this work is to demonstrate the procedure used in the Calibration Laboratory of IPEN for the determination of inherent and additional filtration in order to establish all RQR standard radiation qualities, that represent the radiation qualities in radiation beams emerging from the X-ray tube assembl**y**.

2. MATERIALS AND METHODS

2.1 Installation

This work was developed in the calibration laboratory of instruments (LCI) of the Instituto de Pesquisas Energéticas e Nucleares (IPEN/CNEN-SP).

2.2 Equipment and Systems for Irradiation

The following equipments were used in the LCI for the execution of this project:

2.2.1. Reference system

The dosimetric reference system used is composed of a parallel plates ionization chamber with volume of $1cm^3$, PTW, model 77334, coupled to a PTW electrometer model UNIDOS, type 10001, with traceability to the Primary Standard Dosimetry Laboratory Physikalisch-Technische Bundesanstalt, PTB, Germany. This ionization chamber was calibrated in 2004 according to the first publication of IEC 61267.

2.2.2. X-ray equipment

It was used a radiation system Pantak/Seifert, model HS ISOVOLT, in the clinical radiology operation range (40-160 kV). The tube current applied was 10 or 20 mA depending on the set of qualities established.

2.2.3. Monitor chamber

To monitoring the X radiation beam, it was used an ionization chamber PTW, model TW 34014, serial number 0031, positioned at the exit of the radiation beam just after the additional filtration.

2.2.4. Aluminum filters

For the characterization of the reference radiation qualities, as well as measurements of half-value layer for determining the inherent filtration of X-ray equipment, were used high purity aluminum filters of about 99.9%.

2.3 Determination of Inherent Filtration

The method used for this determination is described in ISO 4037-1 and consists of taking 10 charge readings of 15 seconds each, performed with an amount of additional aluminums filters placed in order to reach the reduction of approximately 50% of the initial charge. The reference system was positioned in the center of the radiation field and the focal detector distance (FDD) was 1 meter. The voltage of X-ray system was adjusted to 60 kV and the tube current of 10 mA. Fig.1 shows the set-up used.

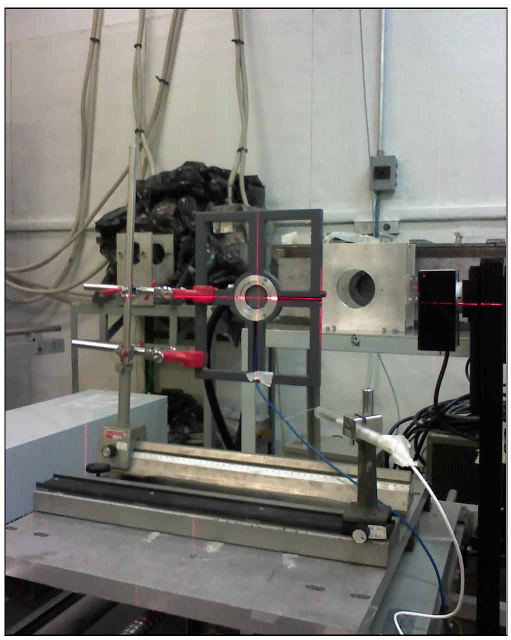

Figure 1. Set-up used for the determination of inherent filtration at the Calibration Laboratory of IPEN.

The inherent filtration found was 0.138 mmAl for one half-value layer (HVL) of 0.1 mm Al. This value was obtained through an extrapolation curve generated from data supplied by ISO-4037-1, as showed in Table 1, in order to make possible the calculation of the inherent filtration because the ISO 4037-1 data only allows the determination of the inherent filtration for the HVL values greater than or equal to 0.33 mmAl. The equation was obtained by a polynomial adjust (5^{th} order).

Table 1: Correlation between HVL for 60 kV and inherent filtration of the X-ray tube, according to the publication ISO 4037-1[1,3].

HVL (mmAl)	Inherent Filtration (mmAL)
0.33	0.25
0.38	0.30
0.54	0.40
0.67	0.50
0.82	0.60
1.02	0.80
1.15	1.00
1.54	1.50
1.83	2.00
2.11	2.50
2.35	3.00
2.56	3.50
2.75	4.00
2.94	4.50
3.08	5.00
3.35	6.00
3.56	7.00

2.4 Determination of Additional Filtration

For the establishment of the “RQR” radiation qualities, initially one attenuation curve for determining the amount of filtering for each “RQR” radiation quality must be done, in order to get the 1st HVL, the 2^{nd} HVL and the homogeneity coefficient.

Each RQR radiation quality has one specific voltage (40 to 150 kV) and in all case the tube current was 10 mA.

For the positioning in the FDD of 1.0 m, the reference point of the ionization chamber was the entrance window. The radiation beam was collimated to obtain a field to cover the entire sensitive volume of the ionization chamber, not exceeding the area determined by the norm[1].

The high purity aluminum filters were positioned at the exit of the X-ray tube in order to moderate and reduce gradually the radiation beam. Measurements were performed for each situation without any additional filtration, and then adding aluminum filters with the thicknesses found previously.

By using the data obtained it was determined one semi-logarithmic scale curve with the attenuation of the beam to aluminum filtration, and then a template was created in a rectangular plastic film, to be "slid" into the chart in order to find the additional filtration for each individual RQR quality. The procedure is detailed in the IEC 61267[1]. Fig. 2 shows oan example of this determination.

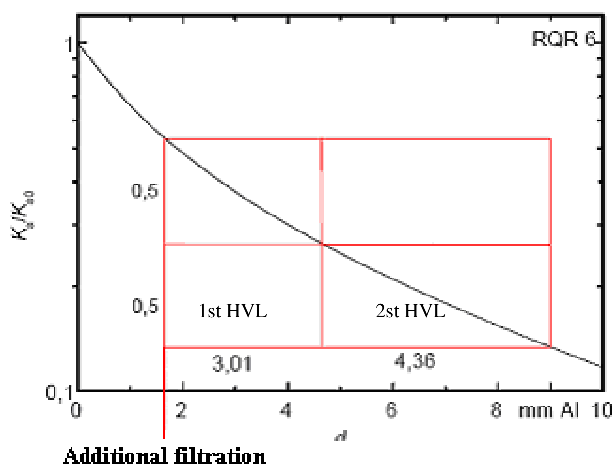

Figure 2: Determination of the additional filtration required to adjust the total filtration to the prescribed value, for the RQR 6 radiation quality.

With the additional filtration already determined by the graph, a fine adjustment of the filtration was made with 3 extra charge measurements with the value of additional filtration found and after that 3 other charges measurements were made with de 1st HVL added as the IEC standard recommends[4,5]. Table 2 shows the main characteristics of the radiation qualities established and the filtration found in each case. The ratio between the initial charge value and the 1st HVL must be between 0.485 and 0.515.

Table 2. Characteristics determined for each quality of radiation RQR.
kQ = beam quality correction factor

Radiation **Qualities**	**Tube Voltage (kV)**	**1st HVL**	**Homogeneity coefficient**	**2nd HVL**	**Additional Filtration**	**kQ**	**Air kerma rates mGy/min**
RQR 2	40	1.42	0.81	1.75	2.3	#	#
RQR 3	50	1.78	0.76	2.34	2.3	#	#
RQR 4	60	2.19	0.74	2.96	2.7	1.011	7.647
RQR 5	70	2.58	0.71	3.62	2.8	0.992	10.219
RQR 6	80	3.00	0.69	4.37	3.0	0.975	11.223
RQR 7	90	3.48	0.68	5.11	3.1	0.962	13.832
RQR 8	100	3.97	0.68	5.83	3.2	0.951	16.249
RQR 9	120	5.00	0.68	7.35	3.5	0.936	21.591
RQ 10	150	6.57	0.72	9.12	4.2	#	#

3. CONCLUSIONS

This work presented the procedure applied for the determination of the parameters recommended by the International Electrotecnhical Commission (IEC) to establish the standard radiation qualities for diagnostic radiology. This methodology was used in the X-ray equipment Pantak/Seifert of the Calibration Laboratory of IPEN. The value for the inherent filtration of X-ray tube that is lower than the value specified in ISO 4037-1[3,4], could be determined by an extrapolation method. Although all values of the additional filtration obtained were inside the range recommended by the IEC[1], a fine adjustment was made in order to get a ratio of exactly 0.500. The obtained additional filtration to the RQR qualities was from 2.3 mmAl (RQR2, 40 kV) to 4.2 mmAl (RQR10, 150 kV). Those qualities now can be applied to calibration of the diagnostic radiology measurements instruments.

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REFERENCES

1. International Electrotechnical Commission. *Medical diagnostic X-ray equipment – Radiations conditions for use in the determination of characteristics*, Standard IEC 61267, Geneva (2005).
2. International Organization for Standardization. ISO 4037-1**:** *Radiation characteristics and production methods***.** Geneva (1996-b).
3. International Atomic Energy Agency. *Dosimetry in Diagnostic Radiology: An International Code of Practice*, IAEA, TRS 457, Vienna, Austria (2007).
4. *P.M.C de Oliveira, Análise de parâmetros característicos de Feixes de Raios X diagnóstico para calibração.* Dissertação (Mestrado em Ciência das Radiações)- Departamento de Engenharia Nuclear da UFMG, Belo Horizonte (2008).
5. M.M.O Ramos, *Padronização da Grandeza Kerma no Ar para Radiodiagnóstico e Proposta de Requisitos para Laboratórios de Calibração.* Tese (Doutorado) - Universidade Federal do Rio de Janeiro (2009).