Comparison between filters with different purities for the HVL determination of X-ray beams

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Abstract. The ISO 4037-1 standard requires the use of aluminium filters with purity of 99.9% for the reference X radiation beam production. The objective of this work was to verify whether lower purity filters may be used for X radiation beam production without significant changes on the attenuation curve characteristics. An intermediate energy beam was chosen for these tests: 60 kV beam, without additional filtration. A cylindrical ionization chamber was used for charge measurements. Initially, the attenuation curve using the aluminium filters with 99.999% of purity was obtained. Then, the same procedure was followed using the aluminium filters with 97.9%, 98.9% and 99.2% of purity. Thereby, taking the curve plotted using the 99.999% of purity filters as reference, the attenuation curves obtained with lower purity filters were compared, diverging from the reference curve only by a maximum of 3%.

KEYWORDS: filter purity; X-ray; standard X-rays beams; calibration of instruments.

1. Introduction

The ISO 4037-1 [1] standard provides the characteristics and production methods of continuous filtered reference X radiation beams for calibrating protection-level dosemeters and rate dosemeters. The standard requires the use of aluminium foils with purity of at least 99.9% for the reference X radiation beam production. Besides, these requirements are also recommended for producing diagnostic radiology beams, as published recently by the International Atomic Energy Agency [2].

The objective of this work was to show that very high purity filters are not necessary, comparing the attenuation curve obtained using aluminium with purity of 99,999%, used in calibration services, and the attenuation curves obtained using lower purity filters (97.9%, 98.9% and 99.2% of purity).

This study was performed at the Calibration Laboratory of the Instituto de Pesquisas Energéticas e Nucleares (IPEN).

2. Materials

Four sets of absorber filters with different purities were tested: three sets were available at Instituto de Eletrotécnica e Energia (IEE/USP) (with purities of: 97.9%, CBA 1050; 98.9%, Potiguar; and 99.2%, CBA 1100) and one set (99.999%, Good Fellow) was from the Calibration Laboratory of IPEN.

The X-ray system was composed by a Rigaku Denki generator, coupled to a Philips tube, model PW 2184/00, with 1 mm of Beryllium window.

A cylindrical ionization chamber (Physikalisch-Technische Werkstätten, PTW, model 23361, 30cm^3 of sensitive volume), calibrated against the secondary standard system (composed by 1 liter ionization chamber, PTW, model LS-01, with traceability to the National Laboratory of Metrology of Ionizing Radiations, Brazil), coupled to a PTW electrometer (model Unidos E), was utilized for the measurements.

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3. Results

The cylindrical ionization chamber was positioned at a distance of 1 m of the focal spot of the X-rays tube. The attenuator support was located at the middle distance between the chamber and the focal spot (0.5 m). This distance minimizes the scattering influence in the readings. The applied voltage to the ionization chamber was 400V.

An intermediate energy beam was chosen for the tests: 60 kV and 30mA, without additional filtration.

Initially, the charge measurements were taken using the aluminium filters with 99.999% of purity. Six consecutive charge readings were taken for each aluminium thickness value. The attenuation curve was plotted. Then, the same procedure was followed using the aluminium filters with 97.9%, 98.9%, and 99.2% of purity. The uncertainties of the measurements did not exceed 0.4% for all sets. Thereby, taking the curve obtained using the aluminium filters with purity of 99.999% as reference, the attenuation curves obtained with lower purity filters were compared.

Figure 1 shows the attenuation curves obtained using aluminium filters with purities of 97.9% and 99.999%. These curves showed divergence of a maximum of 10 %. The maximum standard deviation of this data was 0.4%.

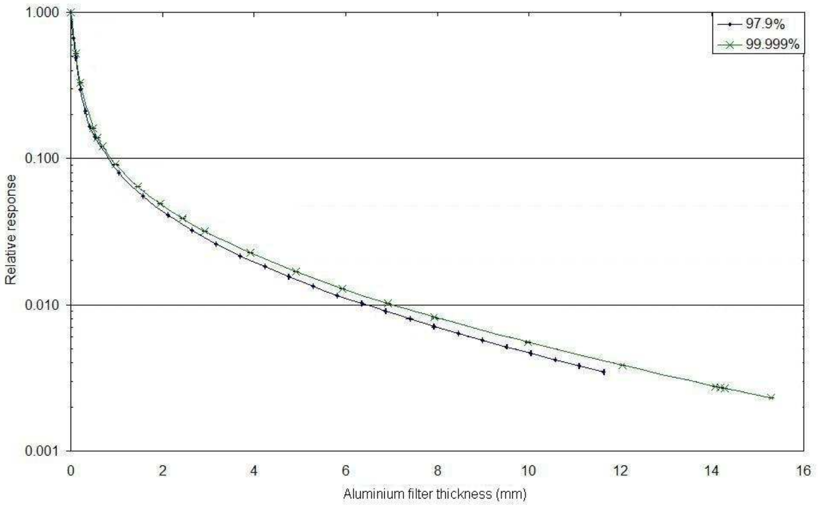

Figure 1: Attenuation curves obtained using aluminium filters with purities of 97.9% and 99.999%

Figure 2 shows the attenuation curves obtained using aluminium filters with purities of 99.999% and 98.9%. These curves diverged only by a maximum of 1.2 %. The maximum standard deviation of this data was 0.1%.

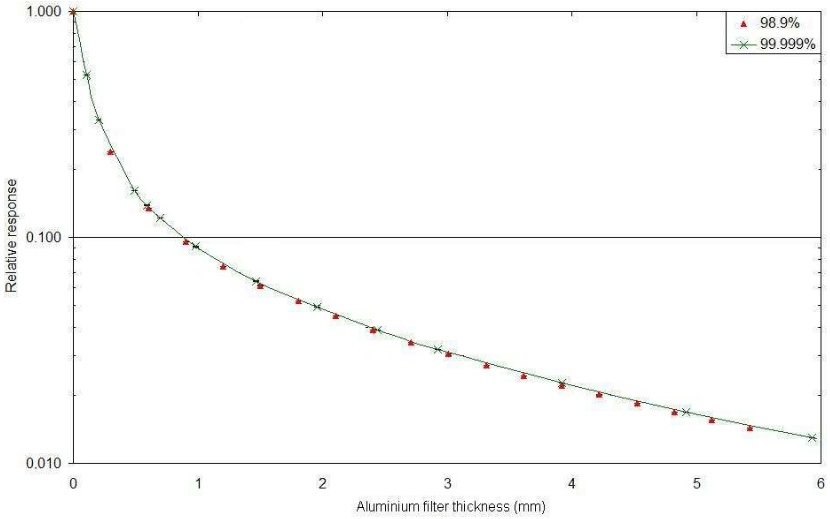

Figure 2: Attenuation curves obtained using aluminium filters with purities of 98.9% and 99.999%

Figure 3 shows the attenuation curves obtained using aluminium filters with purities of 99.999% and 99.2%. These curves diverged only by a maximum of 3.5 %. The maximum standard deviation of this data was 0.2%.

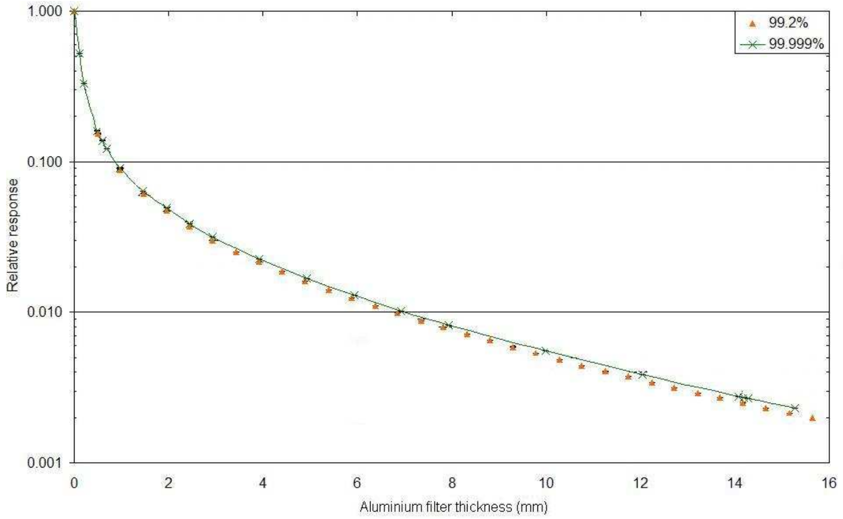

Figure 3: Attenuation curves obtained using aluminium filters with purities of 99.2% and 99.999%

The divergences of the attenuation curves obtained using aluminium filters with different purities are listed in Table 1.

Table 1: Divergences of the attenuation curves for each aluminium filter purity, in relation to the high purity filter of 99.999%.

Aluminium Filter Purity (%)	Attenuation Curves Divergence (%)
97.9	10.0
98.9	1.2
99.2	3.5

4. Conclusion

The results show that the use of aluminium filters with lower purity levels than those required by the standards did not present a considerable influence on the attenuation curves. Therefore, the use of aluminium filters with lower purity levels is feasible and important to be considered for practical and financial reasons.

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