INTER COMPARATIVE STUDY OF ION CHAMBERS RESPONSE FOR LOW AND MEDIUM X RAY DOSIMETRY

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ABSTRACT

In this work the low and medium X ray beam at National Institute for Standards (NIS) was characterized according to ISO 4037 and CCRI beam qualities. Different types of ion chambers response was studied for X ray dosimetry at those beam qualities. The used ion chambers are PTW farmer type 30013,semi flex 31003, flat 31343 and Markus 23343. X ray effective energy was calculated using the Cu half value layer (HVL). The character of energy dependency of different ion chambers were studied and correlated to the attenuation coefficient of the constituting material of each chamber. the attenuation coefficient for graphite, air and PMMA was calculated by winxom software. This work shows that thimble type chambers have a good response to wide range of X ray energies and slight energy dependence under 100 KV. Markus plane parallel chamber has also good response for wide range of X ray energies although it shows more energy dependence than that of thimble chambers.

Keywords: *Ion chamber response – Low & medium X ray – Dosimetry.*

1. INTRODUCTION

Characterization of X ray beam qualities according to ISO 4037 and CCRI is an essential aspect for National Metrology Institutes (NMI's). This is due to the fact that NMI's are responsible to perform their role of providing traceability to the SI units and maintain consistency of measurements on the national level. NMI's should participate in international, Inter-comparisons on basis of either the ISO 4037 or CCRI beam qualities. However NIS would be able to achieve the national requirements of different applications such as the industrial and diagnostic sectors.

X-ray dosimetry is more difficult than gamma ray dosimetry due to its wide energy spectrum. Energy dependence of different ion chambers is the mostly significant parameter in low x-ray dosimetry .So the study of energy dependant response of chambers in low energy x-ray is very important.

electron ionization chambers such as Markus can be used for very low-energy x-ray dosimetry provided that they are used in the restricted energy range for which their response does not change with energy in that range(2,3). This paper evaluates the characteristics of ionization chambers for the measurement of Air Kerma rate for both low and medium-energy x-rays.

2. EXPERIMENTAL WORK

The X ray irradiation facility at the National Institute for Standards (NIS) include X ray tube manufactured by Philips with Kilo voltage range from 20 to 320 KV. Dosimetry systems used were Unidos and Fluke electrometers in addition to different types of ion chambers which are PTW Farmer type 30013,semiflex 31013, flat 23342 and Markus 23343. Also a set of ISO filters of different thickness Cu and AL were used in the verification of the beam qualities and chambers response. The method used to determine the added filtration thickness to verify the ISO beam quality was that of IAEA TRS 457.

3. RESULTS AND DISCUSSION

3.1. Beam quality specification

The verification of NIS beam qualities according to CCRI [1] has been performed for medium X ray at 100,135, and 250 KV. Also for low X ray has been performed at 25 and 50 (a)(El-Sersy et al, 2012 [2]). For the verification of NIS beam qualities according to ISO 4037 [3] , the attenuation of X ray beam was measured by the use of standard dosimetry system and the set of ISO filters described earlier(see Fig. 1).

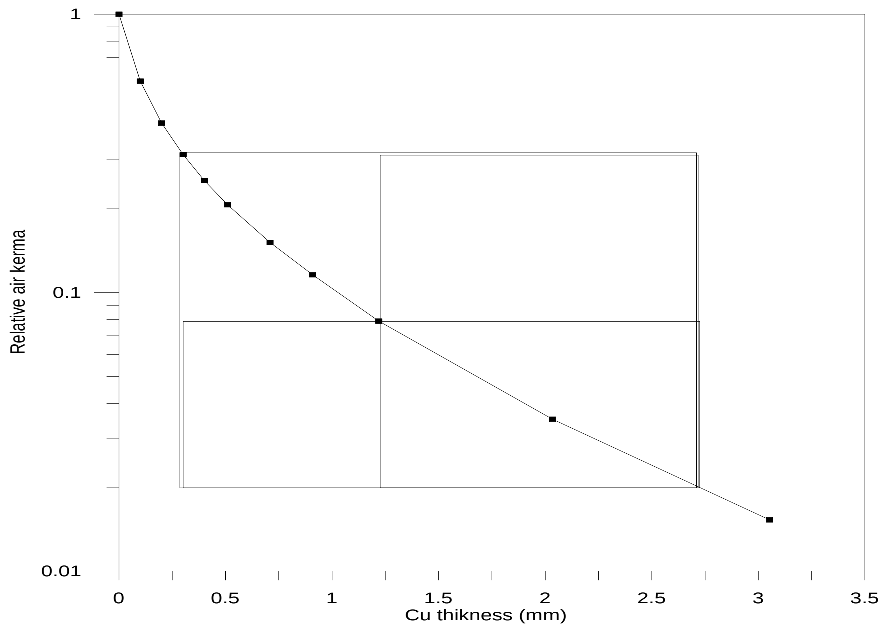
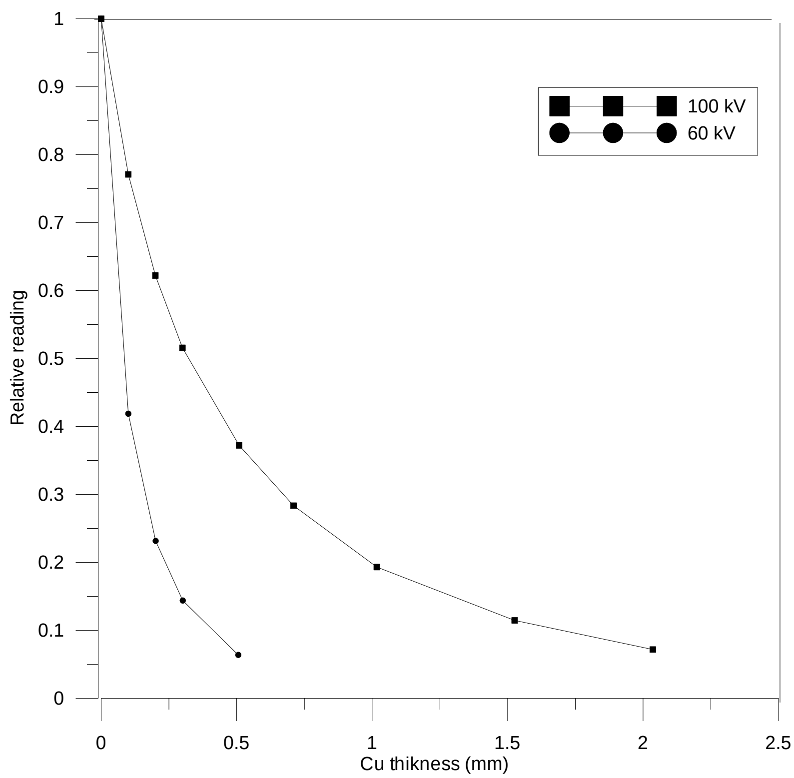


Fig. 1: Relative air kerma as a function of filter thickness in Cu.

(a)



(b)

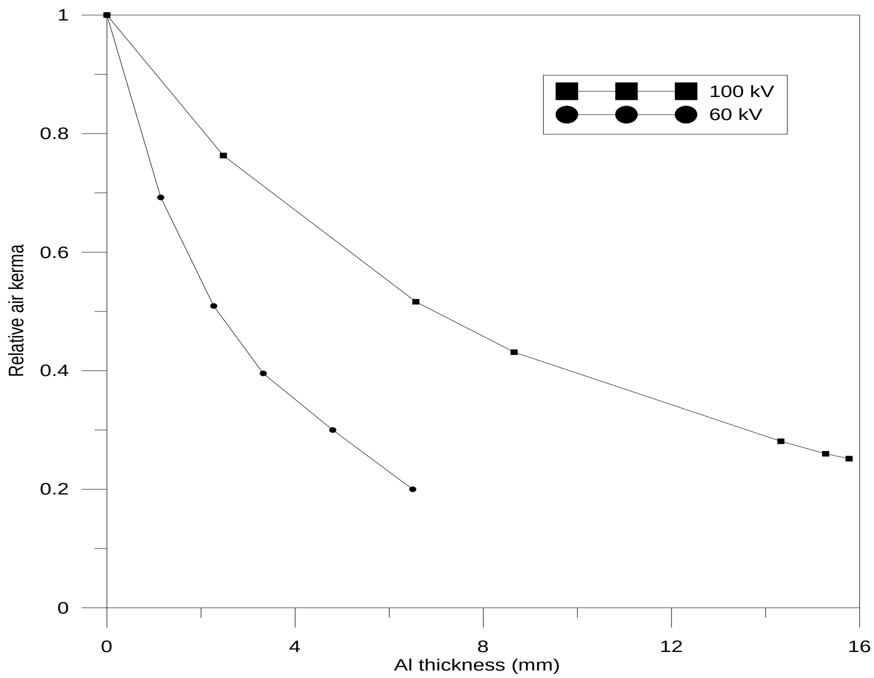


Fig.2: Relative air kerma for 100 and 60 kV X-ray with different (a) Cu (b) Al

The method described at the IAEA TRS 457 for the determination of added filtration thickness required to obtain the precise HVL for either CU or AL filters at a certain KV was used. The two beam qualities obtained were 100 and 60 KV for medium X ray as represented in figure 2 a and b. Values of HVL's in Cu and Al as obtained from figure 2 according to ISO beam qualities of NIS medium X ray are represented in table 1.

Table 1: Values of first HVL Cu and Al for NIS and ISO-4037.

Beam qualities	ISO first HVL	NIS first HVL
100 KV	6.56 mm Al and 0.30 mm Cu	6.7 mm Al and 0.3 mm Cu
60 KV	2.42 mm Al and 0.079 mm Cu	2.4 mm Al and 0.08 mm Cu

3.2. Response of ion chamber for wide range X-ray energies

In this work a set of ion chambers is used for X-ray measurement .Ion chamber specifications are presented in table 2.

Table 2: Specifications of the used ion chambers.

Chamber	Volume(cm^3)	Type	Electrometer
Thimble	0.6	PTW 30013	Unidos
Semiflex	0.3	PTW 31013	Fluke
Flat	0.02	PTW 23342	Unidos
Markus	0.025	PTW TM 23343	Unidos

Both Farmer type and flat ion chambers are reference standard traceable to the SI units measured by BIPM (in 2007) at the CCRI beam qualities of low and medium X ray. So they are used as reference standard for cross calibration of other chambers.

Figure 3 shows the variation of relative Air Kerma rate N_K of different chambers with different KV of X ray beam.

This figure shows that cylindrical chambers Farmer type and semiflex response increase from 25 to 50 kV and is almost non energy dependent in the energy range (50 – 180 KV). Also the figure shows that Markus chamber has higher energy dependence than the cylindrical chambers while the flat chamber response decrease uniformly from 25 to 180 kV. This may be attributed to the small volume of Markus in comparison to that of cylindrical chambers. Also due to the energy dependence of the attenuation coefficient of graphite, air and PMMA (material constituting the chambers). To confirm the above conclusion, the attenuation coefficient for graphite, air and PMMA is calculated by winxom computer program [10] as represented in figure 4.

From this figure it is obvious that the attenuation coefficient decreases strongly up to 50 kev and then almost decreases slightly up to 1 MeV. The relation of attenuation coefficient of graphite and PMMA to air and graphite to

PMMA is illustrated in figure 5. From this figure one can notice that there is increase up to 50 keV and nearly plateau about 1 MeV. Also it is obvious that the behavior of the relation of both graphite and PMMA to air with energy is the same of the relative N_K of the cylindrical chamber (Farmer type and semiflex) but not the same for both Markus and flat that may be attributed to their small volume as compared to the cylindrical ones.
the values of k(ch) determined in this paper agree with those given in the DIN standard within the experimental uncertainty values. These differences were due to dose artifacts generated by the chamber size and the dose gradient.

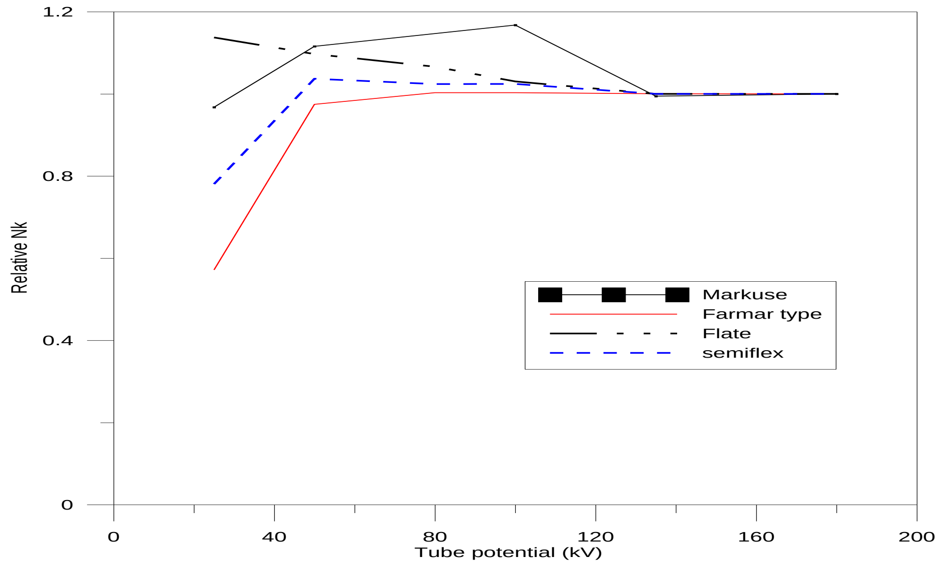


Fig. 3 Relative N_K of ion chambers used as a function of X-ray Kp.

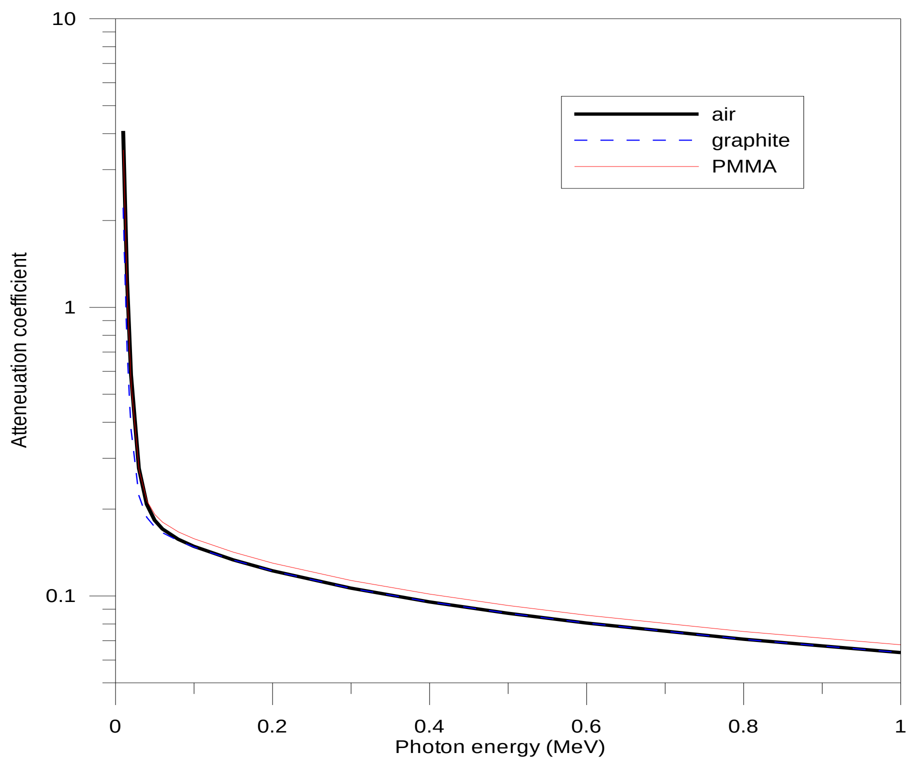


Fig. 4: Attenuation coffiient of graphite, PMMA and air versus X-ray energy.

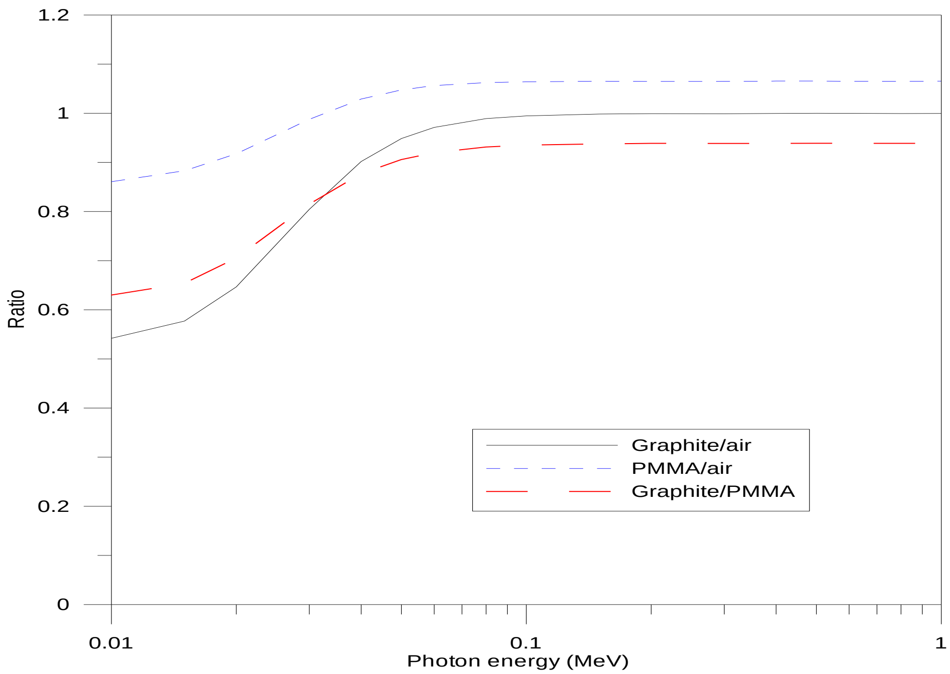


Fig. 5: Variation of relative attenuation coefficient with X-ray energy.

4. CONCLUSIONS

From this work one can conclude that the method described in TRS 457 for determination of added filtration is applicable for the verification of ISO 4037 beam qualities at low and medium X ray. NIS X-ray beam qualities at both low and medium range have been verified according to both CCRI and ISO 4037. So NIS is capable of participating in either of the two type of International inter comparisons. Cylindrical chambers shows stable good response over wide range of X-ray dosimetry and it can be used as secondary Standard chambers at diagnostic level. Markus chamber shows some energy dependence but it is stable at the diagnostic level at the ISO beam qualities than that at the CCRI beam quality.

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