QUALITATIVE ANALYSIS OF X RAY SPECTRA TRANSMITTED BY AN ANTHROPOMORPHIC PHANTOM AND A SHIELDING BARRIER

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Abstract

The X ray beam attenuation considering the X ray fraction transmitted by the patient has not been taken into account in the traditional methods used for evaluating shielding of X ray imaging facilities. Proposed models at present do not consider the hardness of the X ray spectra when the pre-barrier shielding is evaluated. Therefore, the present work proposes the qualitative evaluation of the X ray spectra when transmitted by a set formed by an adult patient (anthropomorphic phantom) and the shielding barrier. For this purpose a group of primary spectra produced using a voltage range from 60 to 140 kV was measured by a CdTe spectrometer system (Amptek, inc.). The X ray system was configured in a RQR 5 beam quality. Another group of X ray spectra transmitted by a barite mortar plate with 15mm of thickness was also measured using the same beam quality and voltage range. Finally, an additional set of X ray spectra including an anthropomorphic phantom (Rando) positioned between the X ray tube and the spectrometer system was measured. Air-kerma measurements were simultaneously measured by using a 30 cm^3 ion chamber (PTW, inc.) calibrated against a national SSDL. Each measured spectra were calibrated and corrected by using a stripping algorithm in order to be presented in plots of (air-kerma/mAs) *vs* energy. The comparative analysis of the spectra in the same voltage shows the high influence of both patient and shielding barrier material. Moreover, the qualitative comparison of the spectra transmitted through patient+barrier and barrier-only sets shows both variations in amplitude and average energy. This kind of evaluation is important to be considered when shielding calculations are performed, but also in the choice of calibration parameters to be adopted when using ion chambers in survey measurements and ambient dose estimations.

1. INTRODUCTION

The use of ionizing radiation sources in medicine must comply with the recommendations of the Publication No. 103 of the International Commission on Radiation Protection [1], referring to the exposure levels to the public and radiation workers. Therefore, optimization methods must be adopted in order to minimize the fraction of the radiation used on medical procedures and which are transmitted to the neighborhood of the rooms where these sources are used.

In order to comply with the radiation protection recommendations, the physical structure of the rooms used in Diagnostic Radiology and Nuclear Medicine must be planned, adequately dimensioned and the walls covered by a desired attenuating material. Therefore, it is necessary to know not only the primary beam of the used radiation, but also the radiation transmitted by the several media, including the patient, related to the processes using ionizing radiation.

Traditional methods of calculating primary barriers in diagnostic X ray rooms consider the beam focusing directly on the structural barrier. The model proposed by Dixon and Simpkin [2], seems to be more realistic when considering, aside from the structural barrier, such devices as cassette and X ray table in the beam attenuation, but, due to practical limitations, does not take into account the effect of beam attenuation on the patient's body. Therefore, the present work proposes a qualitative assessment of transmitted X ray spectrum by a set formed by an adult patient phantom (anthropomorphic phantom) along with a layer of barite mortar. It is expected to present a model closer to reality, which must be taken into account in the proposals of models of shielding specifications.

2. METHODOLOGY

To analyze the influence of the set formed by the patient and protective barrier in an X ray beam quality RQR 5, according to IAEA document TRS457 [3], primary spectra measurements were carried out in a voltage range from 60 to 140kV, using a spectrometer with CdTe detector (Amptek, Inc.). Additionally, transmitted spectra were measured fixing a layer of barite mortar with dimensions of 70×70×1.5 cm^3. Finally, an anthropomorphic adult patient phantom (RANDO phantom) was added between the X ray tube and the barrier, and a new series of transmitted spectra was collected. Simultaneous measurements of air-kerma were carried out using a 30 cm^3 ion chamber (PTW Inc.), calibrated in a national SSDL. The experimental setup is presented in Figure 1.

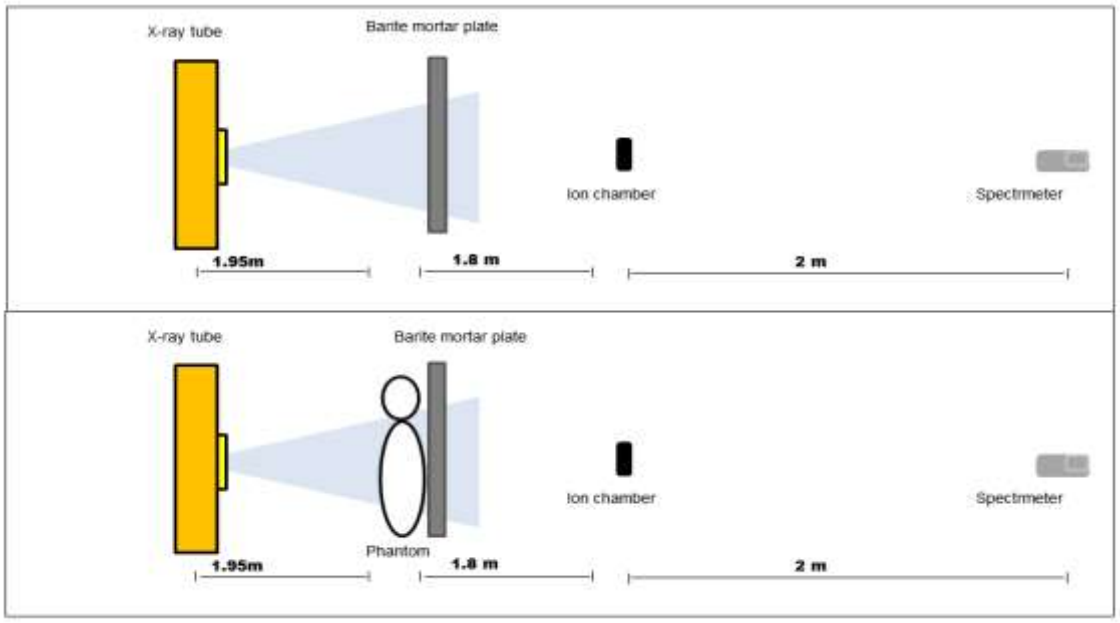
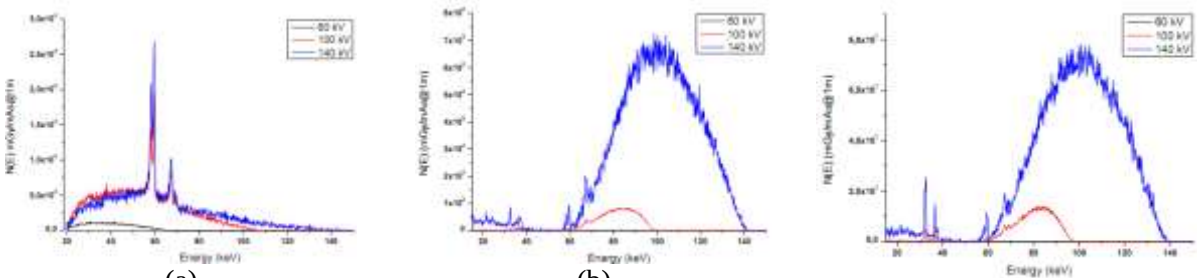


FIG. 1. Experimental setup used for measuring the transmitted spectra.

The measured net spectra were corrected by the detector efficiency, Compton Effect and escape peaks through a Mathlab program developed for this purpose [4]. They were also corrected to a distance equivalent to 1 m of focal point, applying the inverse square distance law. The corrected spectra are presented in values of reason of air-kerma by current-time product (mGy/mAs at 1 m) as a function of energy (keV).

3. RESULTS

Figure 2 presents from left to right the primary spectra, the transmitted spectra by barite mortar and the spectra transmitted by barite mortar plus the adult patient phantom.



(a) (b) (c)

FIG. 2. (a) Primary spectra,(b) the transmitted spectra by barite mortar, and (c) the spectra transmitted by barite mortar plus the adult patient phantom. These spectra were measured using

voltages of 60, 100 e 140 kV, and applying the RQR5 beam quality.

4. CONCLUSION

According to the presented spectra (Figure 2), the radiation beam transmitted through the shielding barrier is significantly attenuated by the barite mortar when it crosses the patient phantom. From this result, it can be concluded that is important to take this kind of effect into account in mathematical models for primary beam shielding calculation.

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