Calibration of semiconductor-based X-ray multimeters in diagnostic radiology beams

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Introduction

Semiconductor-based X-ray multimeters (XMMs) have become the most common dosimeters in use at hospitals. In addition to radiation dose, these multimeters offer the possibility of measuring several quality control parameters by implementing algorithmic corrections to the raw signals. The scope of this study is to evaluate the reliability of the XMMs, calibrated with IEC 61267 standard RQR beams, for HVL measurements in an expanded range of clinically relevant radiation qualities.

Materials and methods

Performances of three different commercially available XMMs in clinical exposure conditions were investigated.: MAKO XMM detector (RTI), Unfors RaySafe – Xi, RadCal (AGMS-D).

Figure 1. XMMs used in this study.

Digital radiography system from Siemens Healthineers was used for several tube voltage settings: 50 kV, 70 kV, 90 kV and 121 kV.

The tube inherent nominal filtration is 2.5 mm Al and the following qualities are considered:

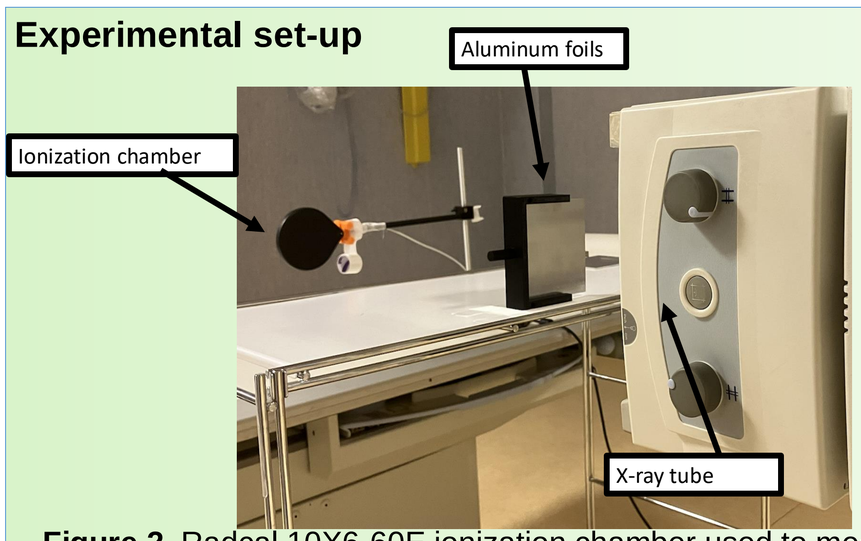
- No filter
- 0.1 mm Cu of added filtration.
- 0.3 mm Cu of added filtration.

Air kerma and half-value layer (HVL) measured with a calibrated ionization chamber (IC) were used as references.

HVL measurement in the clinical facility was performed as described in the IAEA TRS-457, with aluminum filters certified in thickness and purity.

Three HVL measurements were performed for each beam quality, mean values and standard deviations were calculated.

Experimental set-up



For the measurement of the HVL in the clinical facility, a setup with a filter box with a collimator inside it, placed at a distance corresponding to half that between filter and detector, was realised.

Figure 2. Radcal 10X6-60E ionization chamber used to measure HVL on clinical beams.

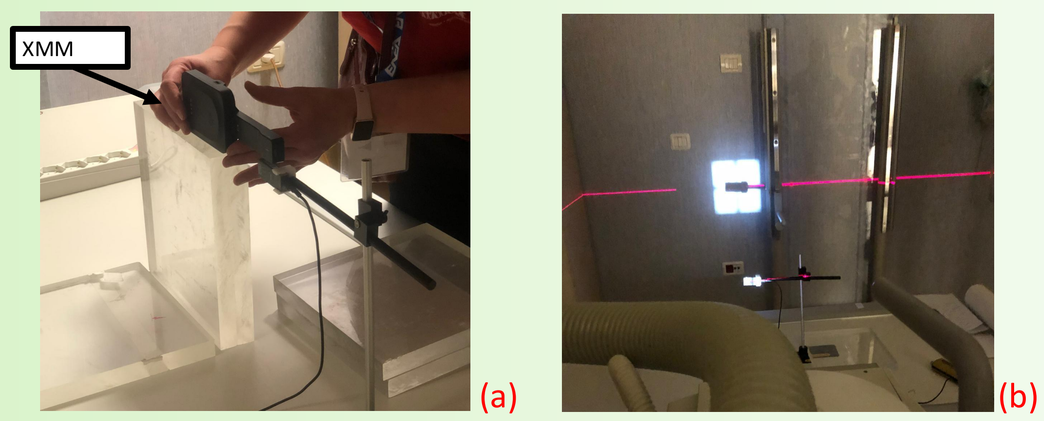


Figure 3. Examples of XMM positioning on clinical beams. Transverse alignment was realised thanks to the field light used in the clinic.

Results

Measured HVL with XMMs are compared with HVL values determined using as reference an ionisation chamber (IC) calibrated in terms of air kerma and Percentage differences were calculated. Results are shown in Figure 4, discrepancies of up to 8 % were found.

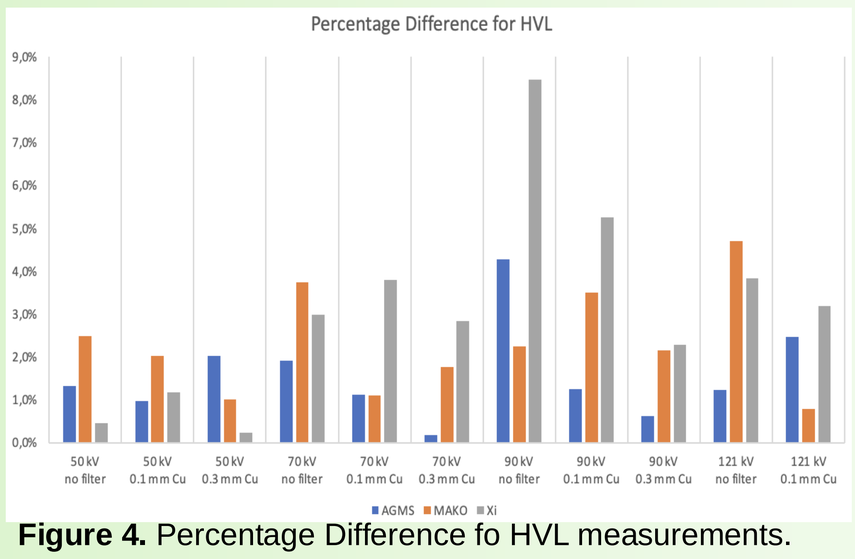


Figure 4. Percentage Difference fo HVL measurements.

HVL calibration coefficients were determined for the three XMMs for the clinical radiation qualities used in the study, Figure 5.

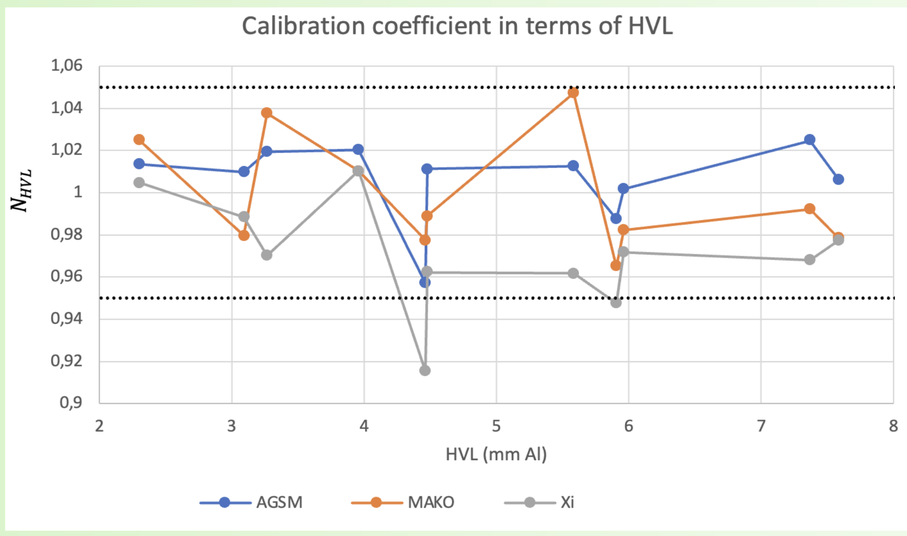


Figure 5. HVL calibration coefficients as function of HVL, dotted lines

Represent the acceptability range conveniently set at 5%.

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Conclusions

The preliminary results indicate that measurements of HVLs using XMMs in standard radiation qualities may not be suitable for use in clinical diagnostic beams. Therefore, calibration coefficients in terms of HVL may be required or, alternatively, an updated set of reference radiation qualities might be required for calibrations to achieve acceptable accuracy in clinically relevant radiation beams.

The study continues and air kerma measurements are now under investigation in order to see how the calibration coefficients in terms of air kerma vary on clinical beams.

Aknowledgments

The project (22NRM01 TraMeXI) has received funding from the European Partnership on Metrology, co-financed from the European Union's Horizon Europe Research and Innovation Programme and by the Participating States.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EURAMET. Neither the European Union nor the granting authority can be held responsible for them.