Calibration of clinical (built-in) KAP meters using a reference KAP meter

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KAP meter built into the collimator housing

KAP meter calibrated by the manufacturer

How can we check the accuracy of the manufacturer's calibration?

Is the strong energy dependence of the KAP meter accounted for?

KAP measurements - what accuracy is needed?

IAEA (2007) and ICRU (2005): uncertainties no more than +/-7% (k=2). Is it possible?

Manufacturers: KAP values are accurate within +/- 20-25%. Is it sufficient?!

Optimizing diagnostic examinations: worth while if gains in dose will be 10-15% at preserved image quality. Is manufacturer's accuracy sufficient?

Setting of DRLs. What accuracy is needed/desired in reporting standard doses to SSM?

Tandem calibration method to test the manufacturer's calibration

Advantages

Most hospital physicist's have access to a KAP meter

The air kerma area product is measured according to its definition including the heel effect

Geometry for the tandem calibration

The reference KAP meter is positioned 20-30 cm below the built-in KAP meter

The whole beam area (including penumbra) must be within the entrance area of the reference KAP meter

The reference KAP meter must not be positioned attached to the collimator housing- errors of about 10% will be introduced

The tandem calibration method was developed at STUK (Toroi *et al* 2008)

Definitions

Air kerma area product

$$P_{KA,Q} = N_{P_{KA},Q_0} M_Q k_{Q,Q_0}$$

Q_0 = calibration quality

Q= user´s quality

Calibration coefficient

$$N_{P_{KA},Q_0} = \frac{P_{KA,Q_0}}{M_{Q_0}}$$

Beam quality correction factor

$$k_{Q,Q_0} = \frac{N_{P_{KA},Q}}{N_{P_{KA},Q_0}}$$

Method to determine beam quality correction factors for the reference KAP meter

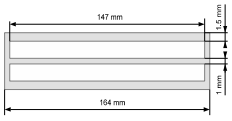
The response of the reference KAP meter (Vacutec 70157) was calculated using Monte Carlo simulations

Energy spectra were derived using the SpekCalc program (Poludniowski *et al* 2009)

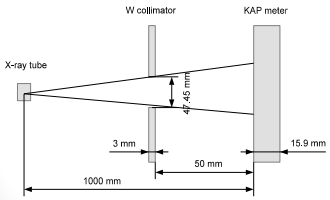
Beam quality correction factors were calculated for the reference beams at SSM (RQR, RQA) and the spectra from Siemens Aristos x-ray stand using simulations and calculated energy spectra

Calculated beam quality correction factors were validated experimentally

Simulation model of the KAP meter



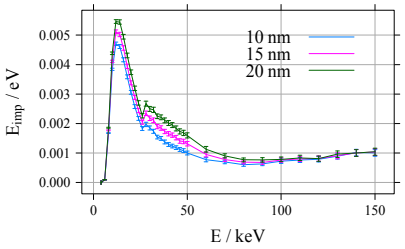
KAP meter model
3 layers of PMMA
The PMMA layers are coated with thin layers of InO



Calibration geometry at SSM
Incident radiation

Results

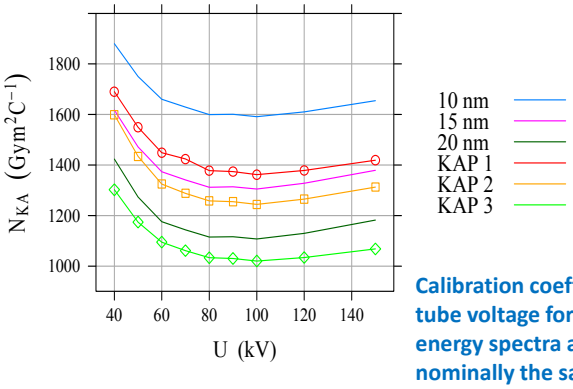
Response of the KAP meter - monoenergetic photons



Energy imparted to the air volume of the KAP meter as function of photon energy. Thickness of In-layer is parameter

Results- Calibration coefficients SSM beams RQR series

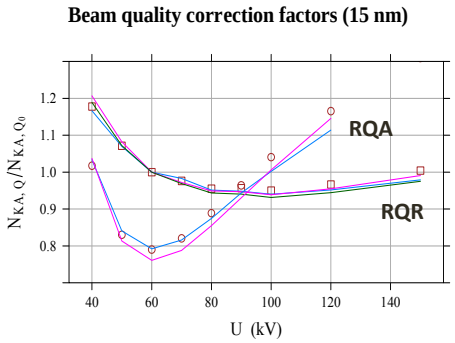
Calibration coefficients (RQR)



Calibration coefficients as function tube voltage for the RQR series of energy spectra and 3 KAP meters of nominally the same make (Vacutec 70 157)

Solid lines: simulations
Markers: experimental values

Results-Beam quality correction factors SSM beams RQR and RQA series



Solid lines: experimental values for 2 different KAP meters

Markers: simulated values for KAP meter with 15 nm In-coating

Beam quality correction factors as function of tube voltage for the RQR and RQA series of energy spectra

Reference beam RQR4

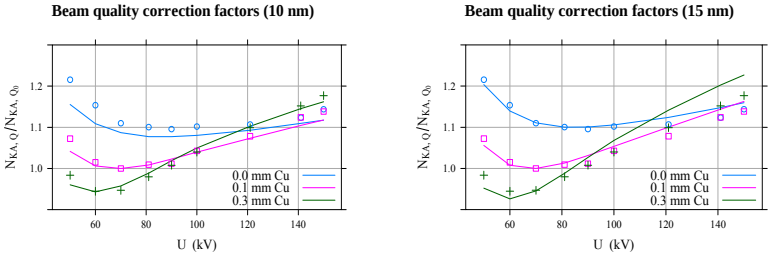
Validation of calculated beam qaulity correction factors for clinical beams

Exprimental set-up

Measurement with an energy independent ion chamber 20 cm above the patient coach

Spherical Shonka-Wyckoff ion chamber, model A3

Results-Beam quality correction factors Clinical beams Siemens Aristos



Simulations :solid lines)
Experiments: markers

Reference beam: 70 kV, 0.1 mm Cu

Results for the lowest and largest filtrations are sensitive to the thickness of the coating layer. More accurate x-energy spectra may be needed which could possibly be achieved with better information on inherent filtration and target properties. SpelCalc is limited to W as target material.

Result –accuracy

Manufacturer's calibration in error by up to 26% !

Conclusions

MC calculation facilitates beam quality correction factors

Beam quality correction factors applied by tabulation or soft ware

Access to reference beams with heavy Cu filters is needed

References

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