Experimentally determined k_Q values at the IAEA Dosimetry Laboratory (DOL)

Zakithi Msimang; Reham Hammam; Joao Cardoso, Alhanouf Aldosari; Mauro Carrara
International Atomic Energy Agency (IAEA), Vienna, Austria

2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

ABSTRACT

In 2022 the IAEA Dosimetry laboratory (**DOL**) established the capability of calibrating ionisation chambers in linac photon beam. This has allowed the laboratory to experimentally determine the k_Q for Farmer chambers individually following TRS 398 (Rev.1) and the methodology for the dissemination of megavoltage photon-beam calibrations from the IAEA Dosimetry Laboratory to SSDLs and end users (see SSDL Newsletter 77).
The IAEA obtains its measurement traceability from the BIPM, and upon user's request and programmatic justification, it calibrates in five high energy photon beam qualities plus a Co-60 beam, 6 MV, 8 MV 10 MV 15 MV and 18 MV. The $TPR_{20,10}$ – namely the beam quality specifier according to TRS 398 (Rev.1) - for the five beams is 0.665, 0.710, 0.737, 0.760 and 0.780 respectively. The measurement uncertainty associated with the determination of the calibration coefficients in LINAC beams is about 1 % and 0.8 % for Co-60.

Chambers studied in this work are the IBA FC65-G and PTW 30013. Measurements were performed in a horizontal beam set up. Tabulated and measured beam quality correction factors k_Q were compared.

Beam quality correction factors k_Q were determined for 9 IBA FC65-G and 12 PTW 30013 individually. The highest variation compared to the published data for a chamber model and energy observed was 0.5%. The data are consistent with the standard uncertainty associated to the tabulated k_Q given in IAEA TRS 398 (Rev.1) which is 0.6%.

Results show limited differences between calculated and measured k_Q values for the IBA FC65-G and PTW 30013 chambers calibrated in photon beam energies. The IAEA will continue collecting and monitoring the results.

CONTACT

Carrara, Mauro
Internation Atomic Energy Agency
Vienna International Centre, PO Box 100,
1400 Vienna, Austria
M.Carrara@iaea.org
(+43-1) 2600- 21653

INTRODUCTION

The determination of absorbed dose to water for reference dosimetry of a linac machine, described in **IAEA TRS-398 (Rev.1)**, uses the beam quality correction factor (k_Q) to transfer calibration coefficients from the reference Co-60 beam to clinical photon beam qualities.
The recent establishment of high-energy photon beam calibration capability at the IAEA Dosimetry Laboratory (DOL) enables the experimental determination of chamber-specific k_Q values and provides an opportunity to compare these values with the tabulated data in TRS-398 (Rev.1).

PURPOSE

To present measured beam quality correction factors (k_Q) determined at the IAEA DOL for the IBA FC65-G and PTW 30013 Farmer ionization chambers and compare these with those tabulated in IAEA TRS-398 (Rev.1).

METHODS AND MATERIALS

- The IAEA DOL established its LINAC photon beam calibration capability in 2022 for 6 MV, 8 MV 10 MV 15 MV and 18 MV with $\boldsymbol{TPR_{20,10}}$ beam quality index (0.6651, 0.7097, 0.7374, 0.7603 and 0.7802 respectively).
- The methodology for the dissemination of megavoltage photon-beam calibrations $N_{D,w,Q}$ from the IAEA DOL to SSDLs is provided in IAEA SSDL Newsletter 77.

- In this study, a total of 21 farmer-type ionization chambers were evaluated (9 IBA FC65-G; 12 PTW 30013).
- Data used for $N_{D,w,Q}$ were obtained from calibrations performed since 2022 in five high-energy photon beam qualities Q.
- The Co-60 reference beam served as the calibration reference quality.
- Beam quality correction factor ($\boldsymbol{k_Q}$) was determined using

$$k_{Q} = \frac{N_{D,w,Q}}{N_{D,w}}$$

Where:
- Q: photon beam quality
- $N_{D,w}$: Absorbed dose-to-water calibration coefficient in Co-60
- $N_{D,w,Q}$: Absorbed dose-to-water calibration coefficient in the photon beam quality Q

REFERENCES

1. McEwen MR. Measurement of ionization chamber absorbed dose k(Q) factors in megavoltage photon beams. Med Phys. 2010 May; https://doi.org/10.61092/iaea.ve7q-y94k
2. INTERNATIONAL ATOMIC ENERGY AGENCY, SSDL Newsletter Issue No. 77, May 2023 , SSDL Newsletter No. 77, IAEA, Vienna (2023)
3. McEWEN, M.R., Measurement of ionization chamber absorbed dose k_Q factors in megavoltage photon beams, Med. Phys. 37 (2010) 2179–2193, doi: 10.1118/1.3375895
4. ANDREO, P., et al., Determination of consensus k (Q) values for megavoltage photon beams for the update of IAEA TRS-398, Phys. Med. Biol. 65 (2020) 095011, doi: 10.1088/1361-6560/ab807b.

FIG. 1: Reference conditions for calibration in terms of absorbed dose to water in linac photon beams at the IAEA DOL

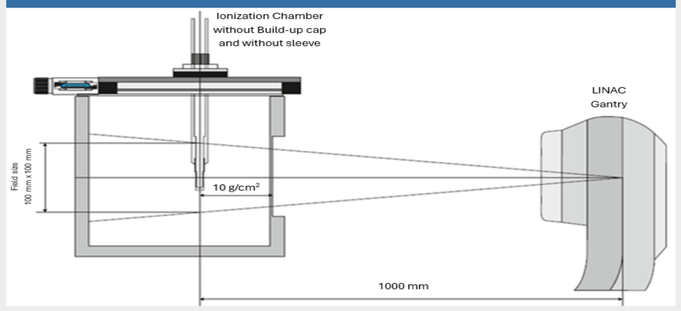
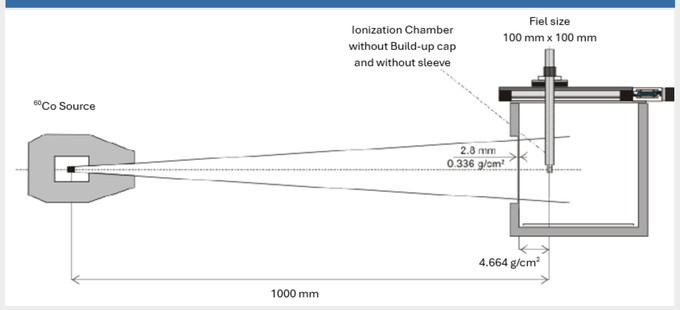


FIG. 2: Reference conditions for calibration in terms of absorbed dose to water in Co-60 Gamma beam at the IAEA DOL



RESULTS

FIG. 3 Calculated k_Q values at DOL/IAEA and data from TRS 398 (Rev.1) as a function of $TPR_{20,10}$

k_Q values from TRS 398 (Rev.1) for farmer type ionization chambers as a function of IAEA DOL beam quality index $TPR_{20,10}$

MV	DOL Beam quality				
	6 MV	8 MV	10 MV	15 MV	18 MV
$TPR_{20,10}$	0.6651	0.7097	0.7374	0.7603	0.7802
Ionization chamber type	k_Q				
IBA FC65-G	0.9930	0.9865	0.9808	0.9747	0.9682
PTW 30013	0.9899	0.9821	0.9759	0.9698	0.9636

Measured k_Q values at IAEA DOL for farmer type ionization chambers as a function of IAEA DOL beam quality index $TPR_{20,10}$

MV	DOL Beam quality				
	6 MV	8 MV	10 MV	15 MV	18 MV
$TPR_{20,10}$	0.6651	0.7097	0.7374	0.7603	0.7802
Ionization chamber type	k_Q				
IBA FC65-G	0.9918	0.9853	0.9794	0.9739	0.9682
PTW 30013	0.9883	0.9803	0.9737	0.9679	0.9624

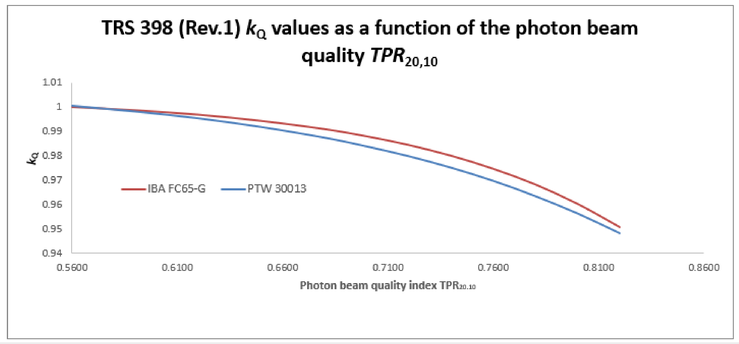


FIG. 4 Comparison of k_Q values determined at IAEA DOL with values published in TRS 398 (Rev.1)

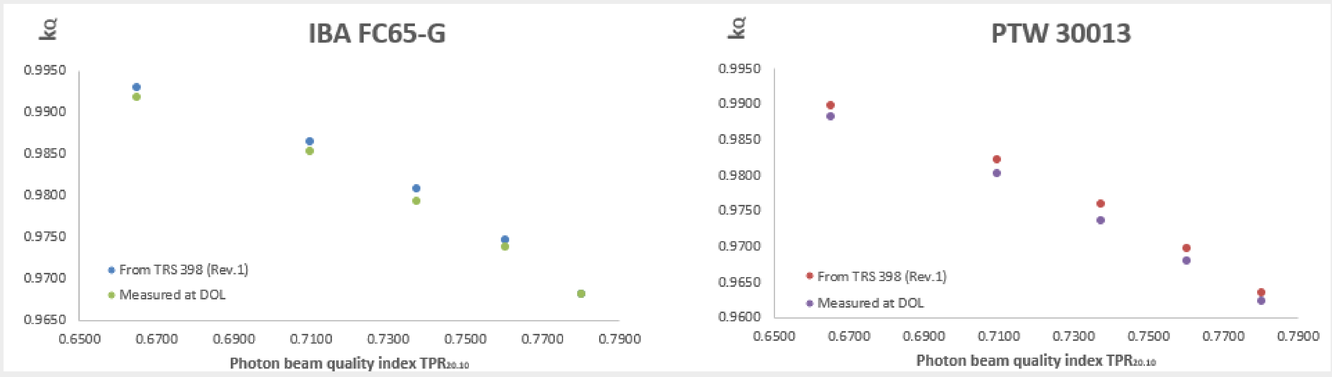
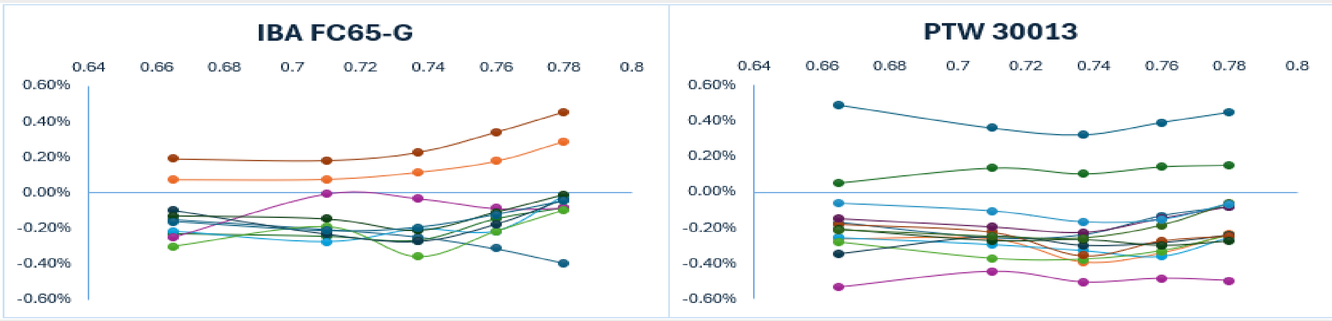


FIG. 5 Relative difference (%) between k_Q values determined at IAEA DOL with values published in TRS-398 (Rev.1)



DISCUSSION

- The measured k_Q values showed good agreement with the reference values published in IAEA TRS-398 (Rev.1) taking into consideration the measurement uncertainties.
- The combined standard uncertainty for the determination of k_Q at IAEA DOL is about 0.6 % and same in TRS 398 (Rev.1).

CONCLUSION

- The measured k_Q values closely followed the reference values published in TRS-398 (Rev.1) across all investigated beam qualities and ionization chambers.
- The new calibration capability at the IAEA DOL supports continued monitoring of beam quality correction factors.