Australian Government
Australian Radiation Protection and Nuclear Safety Agency

arpansa

Australian Clinical Dosimetry Service

FFF Dosimetry ACDS Fact Sheet

Introduction

The ACDS has extended its audit modalities to include Flattening Filter Free (FFF) beams. This fact sheet discusses the various issues that need to be considered for FFF reference dosimetry which underpins the measured audit doses across all levels of audit (Lye 2016).

Energy Correction

The two most commonly used protocols for reference dosimetry in external beam radiotherapy are IAEA TRS-398 and AAPM TG-51. Increasingly flattening filter free (FFF) linacs are in clinical use and published theoretical analysis has suggested that a difference of 0.5 % is expected between the two protocols (Xiong 2008) due to sensitivity of k_Q as a function of $TPR_{20,10}$ to the removal of the flattening filter. The Australian Clinical Dosimetry Service (ACDS) has measured FFF beam dose outputs on 11 linacs using a Farmer type PTW 30013 chamber using both TRS-398 and TG-51 protocols. Measured differences in dose output derived from TRS-398 and TG-51 protocols were less than 0.1 % for 6 MV FFF beams and less than 0.2 % for 10 MV FFF beams.

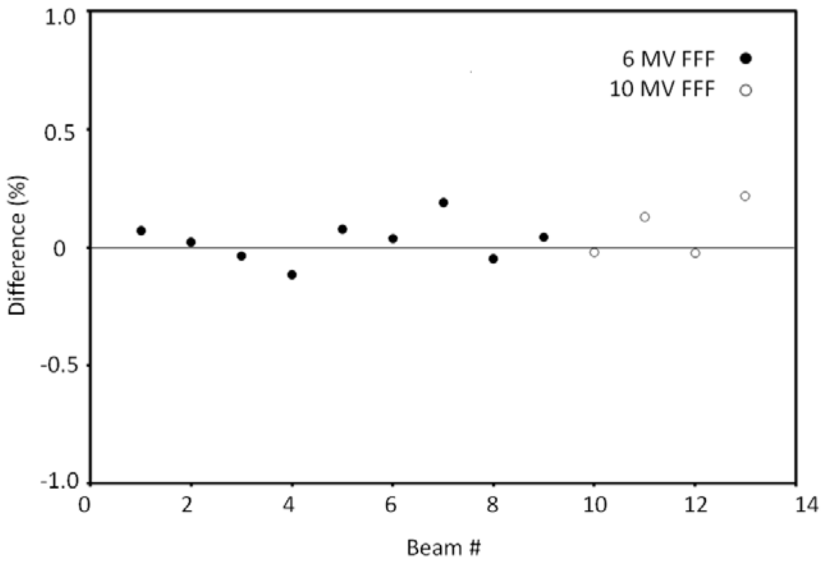

Figure 1 Difference in measured output of all 6FFF and 10FFF beams using TRS-398 compared to TG-51(addendum).

The response of an NE2561 chamber was modelled using DOSRZnrc. The model was used to study the difference in k_Q in Varian and Elekta linacs when the flattening filter was removed, and when the flattening filter was replaced by a thin metal plate. The model with the flattening filter completely removed showed k_Q (as a function of $TPR_{20,10}$) 0.6 % lower than the k_Q with flattening filter (WFF). The commercial realisation of FFF beams includes a thin metal filter in the place of the flattening filter. When a 2 mm metal plate was included in the model, the difference between the FFF k_Q and the WFF k_Q was reduced to approximately

0.1%. The modelling suggests the thin metal plate used in place of the flattening filter offers sufficient filtration for the FFF beam to produce a similar k_Q to WFF beams.

Non-uniformity

The non-uniformity corrections were calculated from beam profiles at 10 cm depth by summing the ratio of the central axis dose to the point dose over the long axis. Profiles were obtained from a Varian Truebeam and from an Elekta Versa. The corrections are shown in Table 1. The non-uniformity corrections (0.30% to 0.45% at 10 cm depth) are large enough to warrant inclusion in the reference dosimetry.

Table 1 Non-uniformity corrections for the 6MV FFF and 10MV FFF beams at 10 cm depth.

Beam	k_n Elekta	k_n Varian	k_n Average
6 MV FFF	1.0036	1.0025	1.0030
10 MV FFF	1.0042	1.0048	1.0045

Recombination

The maximum recombination correction for a PTW 30013 at 400 V was 1.0%, comfortably in the region where the two voltage method is suitable (Boutillon 1998). Note that this is only valid for the particular chamber type and voltage combination used. The maximum difference in recombination between 10 cm and d_{max} was 0.28%, resulting in a change to k_Q of only 0.04%.

Summary

The ACDS is using TRS-398 to perform reference dosimetry on FFF beams, and also using a beam non-uniformity correction.

References

J E Lye, D J Butler, C P Oliver, A Alves, J Lehmann, F P Gibbons, and I M Williams, Comparison between the TRS-398 code of practice and the TG-51 dosimetry protocol for flattening filter free beams, Phys. Med. Biol. **61** N362-N372 (2016)

M. Boutillon, Volume recombination parameter in ionization chambers, Phys. Med. Biol. **43** 2061-72 (1998)