Ion recombination correction factor \( k_s \) in medium dose rate for Advanced Markus ionization chamber

Different electron energies (3, 5, 7 and 9 MeV) together with 100, 60 and 40 mm applicators were used to produce dose per pulse ranged from 4 to 41 mGy/pulse. Film calibration was done by a stem chamber irradiated with 6 MV photons (Precise, Elekta AB, Stockholm, Sweden) in 5 cm depth of small water phantom type T41023 (PTW-Freiburg, Freiburg, Germany). Film digitalization was done with a commercial flat panel scanner Perfection V750 PRO (Epson, Nagano, Japan). They were analyzed by OmniPro I’tmRT software (IBA Dosimetry, Schwarzenbruck, Germany). For each beam an individual 5 x 5 cm\(^2\) film sheet was positioned perpendicular to the beam central axis at the reference depth \( Z_{ref} \). The reference depth was determined by the formula recommended in IAEA-TRS-398. The reference value of \( k_s \) was determined in a way that the \( D_{ref} / d_w \) should be unity. The absorbed dose in water \( d_w \) is not corrected for ion recombination. \( D_{ref} \) is the absorbed dose measured by the film. The value of reference \( k_s \) was derived as:

\[
k_s = \frac{D_{ref}}{d_w}
\]

The recombination factor \( k_s \) at the normal operating voltage \( V_1 \) obtained from:

\[
k_{s,TV} = a_0 + a_1 \left( \frac{M_1}{M_2} \right) + a_2 \left( \frac{M_1}{M_2} \right)^2
\]

The details of equation 2 and the constants \( a_i \) are given in IAEA-TRS-398 protocol. New modified Boag’s formulas are as following:

\[
f' = \frac{1}{u} \ln \left( 1 + \frac{e^{p_1 u} - 1}{p} \right)
\]

\[
f'' = p + \frac{1}{u} \ln[1 + (1-p)u]
\]

\[
f''' = \lambda + \frac{1}{u} \ln[1 + \frac{e^{\lambda(1-\lambda)u - 1}}{\lambda}]
\]

The details about these expressions are discussed in Boag, Hochhäuser and Balk (1996) and Laitano et al (2006). Figure 1 shows the result obtained by Advanced Markus chamber.

![Figure 1](image)

**Figure 1.** Comparison of \( k_s \) value as a function of electron energy determined by eq. 2, 3, 4 and 5 and normalized by reference value obtained by eq. 1 for 100, 60 and 40 mm applicator (from left to right).

**References**

