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Calculation of The Relative Tray Transmission Factor For The Co-60 Teletherapy Unit

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ABSTRACT

Relative tray transmission factor (RTF) have been determined for two types of trays as a function of field size and source – surface distance (SSD) for Co-60 gamma – ray beam with energy (1.25 MeV). The results show an increase of the relative tray transmission factor with increase field size up to (2.22) and (1.176) for the PMMA tray, and Al tray respectively when the field size is (25 cm x 25 cm) at (SSD = 60 cm).

This result indicates that the relative tray transmission factor variation with field size is related to a change of the primary photon flounce. Our study also shows that the (RTF) decreases with increasing source – surface distance (SSD) from (60 cm) to (80 cm) for the same type of trays due to a reduced contribution to the total dose from photons scattered in the trays.

حساب عامل النفاذية النسبي للصينية المستخدمة في وحدة الكوبلت- 60 العلاجية

الملخص

تم احتساب عامل النفاذية النسبي لنوعين من الصينيات كدالة لحجم المجال والمسافة بين المصدر والسطح لحزمة أشعة كاما لمصدر الكوبلت – 60 ذات الطاقة (1.25 MeV). وقد بينت النتائج وجود زيادة في عامل النفاذية النسبي للصينية مع زيادة حجم المجال إلى (2.22) و(1.176) لصينية البلاستك والألمنيوم على التوالي عند حجم المجال (25 cm x 25 cm) وSSD= 60 cm. تشير هذه النتائج بان تغير عامل النفاذية النسبي للصينية مع حجم المجال كانت نتيجة التغيير بتدفق الفوتونات الأولية. وقد دلت دراستنا أيضا بان عامل النفاذية النسبي للصينية يقل مع زيادة المسافة بين المصدر والسطح من (60 cm) إلى (80 cm) لنفس النوع من الصينيات نتيجة نقصان أو انخفاض مشاركة الفوتونات المتشتتة بالصينيات في الجرعة الكلية.

INTRODUCTION

Tray and block trays are routinely placed in the primary beam of teletherapy machine to: a. Shield vital structures within the beam (e.g lung shield) or b. To optimizing dose distributions (Venselaar, 2000). The radiation output in the presence of tray is characterized by the tray transmission factor and open beam field size factors. When the photons interacts with the tray materials, there is attenuation of the primary radiation due to these interactions, so it can be expected that the tray transmission factor will vary with collimator setting (field size), with the sourc to – surface distance and with the distance from the tray to the measuring point (Van Kleffens et al., 2000).

Several authors have investigated the effect on the output factor of beam by the presence of beam modifiers (tray, block tray) (Huang et al., 1986, Islam and Van Dy, 1995, Yu Mk and Sloboda, 1997). The influence of field size on the tray transmission factor was reported to be negligable by (Sharma and Johnson, 1994), but there data were limited to fields within equivalent square of only (15 cm x 15 cm). Tatcher and Biarngard (1994), studied fields up to (20 cm x 20 cm) using a (0.97g. cm^{-2}) acrylic block tray, but found a negligible contribution to head scatter from the block tray and the shielding blocks. (VanDam et al., 1992) pointed out that incases where the field of view on the flattening filter from the point of measurement is shielded by the blocks, the primary photon flounce can be modified, it is noted that for such cases rather extreme blocking close to the collimator rotation axis must be applied.

More recently Jursinic (1999), studied the change in the incident primary photon flounce in 6 and 18 MV beams caused by blocks and block trays and found that the total (block tray factor) can be as much as (3%) larger than the single value tray factor that is obtained from measurements in the reference field, depending on the geometry due to the block on the tray. (Schaeken and VanLoon, 1988), suggested quantifying the influence of the tray on depth – dose data by separate measurements in open field and in fields with tray to be able to include differences in depth-dose in dose calculations, especially in the first few centimeter below the surface. They observed a considerable loss of skin sparing and shift of (d max) due to increased electron contamination in beam with tray.

METHOD AND MATERIALS

The determination of relative tray transmission factor (RTF) was performed using two types of trays, these are polymethylmethacrylate (PMMA) which is plastic plate transparent to light from the light localizer and aluminum (Al) usually used in oblique incident. So to support lead blocks used to shape beams of high-energy photons, these trays often is positioned strongly in its place at the head of the machine between the collimator and the patient by bracket. The width of them were (1.3cm, 0.48cm) respectively. The source – surface distance (SSD) used in this determination were (60cm, 70cm and 80cm) and the field size were varying between (10 cm x 10 cm) and (25 cm x 25 cm)for each SSD.

The (RTF) were found from the equation given by (Heukelom et al., 1994, 1995), which was later modified by Thomas (1994), include the variation in position of the wedge in the beam.

For trays the equation is:

$$RTF(V,d,f) = 1+C.\Delta V. (A+B)^2 / (A^2 . B^2) \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

C is the parameter with the dimension (cm^{-1}) which is in principle dependent on the beam quality and the scattering properties of the tray material, ΔV is the difference between the irradiated volume of the tray materials as absorbed from the point of measurement relative to the volume in the reference field, and (A), (B) are the source-tray distance and the tray-surface distance, respectively (with f = A + B) as shown in Fig (1). ΔV is derived from the product [d. (V^2 - 10^2). (A / SSD)^2], in which (d) is the thickness of the tray, (V) is equal to the side of the square field at (SSD) (VanKleffens et al., 2000). Since the secondary radiation from the tray consists of scattered photons, a better choice for parameter (C) might be use the product of the scatter coefficient (μ / ρ) – (μ_{en} / ρ) and the density (ρ) in this equation, rather than the product of the mass energy - absorption coefficient (μ_{en} / ρ) and (ρ), as was argued by (Thomas, 1994). For the beam qualities used in this study, the value of (C) was (0.0879), (0.0345) for PMMA and Al tray respectively.

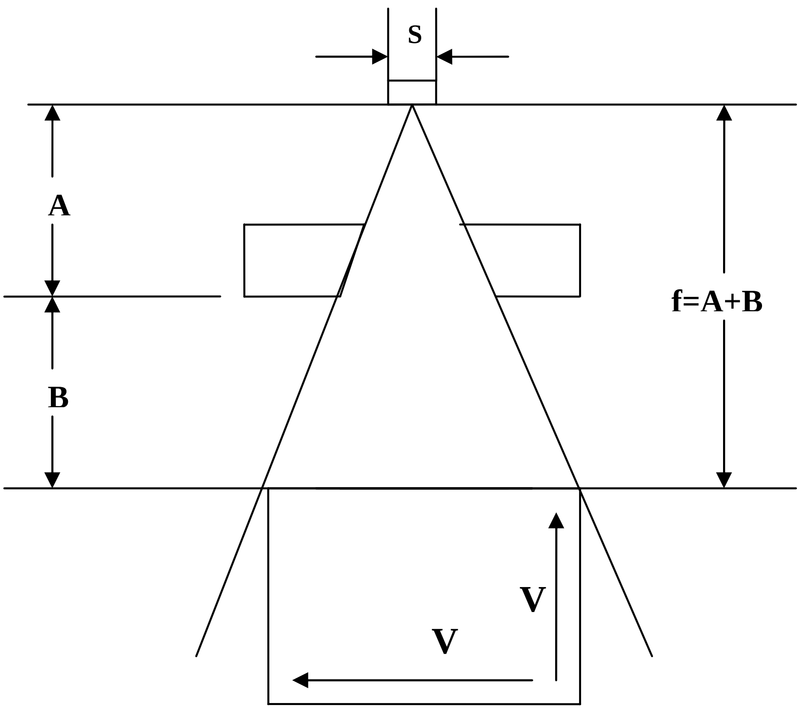

Fig. 1: schematic diagram used to calculate the RTF.

Appling eq(1), the calculations were first made with the PMMA tray (ρ = 1.18 g/cm^3), SSD = 60 cm and changing the field size (V) from (10 cm x10 cm) to (25 cm x25 cm) so that the distance from the tray to the surface (B) is equal to the (7 cm).

Second we change only the SSD to (70 cm) and use the same type of tray and the same field sizes, so that the value of (C) and the distance from the source to the tray (A) remains unchanged, while the distance from the tray to the surface (B) varies, (B=17 cm).

At last we change the SSD to (80 cm) using the same try and field sizes, in this case the distance from the tray to the surface was (B = 27 cm).

Similar calculations were made with the Al tray ($\rho = 2.68\ g/cm^3$), by applying eq.(1) and by changing the filed sizes, the SSD, the source-tray distance we found the values of RTF for Al tray.

RESULTS

The relative transmission factor (RTF) as a function of field size for gamma ray with energy (1.25 MeV) are shown in Fig (2). This figure shows the RTF for two types of trays, PMMA-tray, and Al-tray, for the source–surface distance equal (SSD = 60 cm). As illustrated in Fig. (2), RTF for Al trays is increase from (1) to (1.176) when the field size increase from (10 cm x10 cm) to (25 cm x 25 cm), and for PMMA tray is increase from (1) to (2.22) when the field size increase from (10 cm x 10 cm) to (25 cm x 25 cm).

The RTF when t he SSD = 70 cm, increase from (1) to the (1.029), and from (1) to the (1.20) when the field size increase from (10 cm x 10 cm) to (25 cm x 25 cm) for Al tray and PMMA tray respectively as shown in Fig. (3).

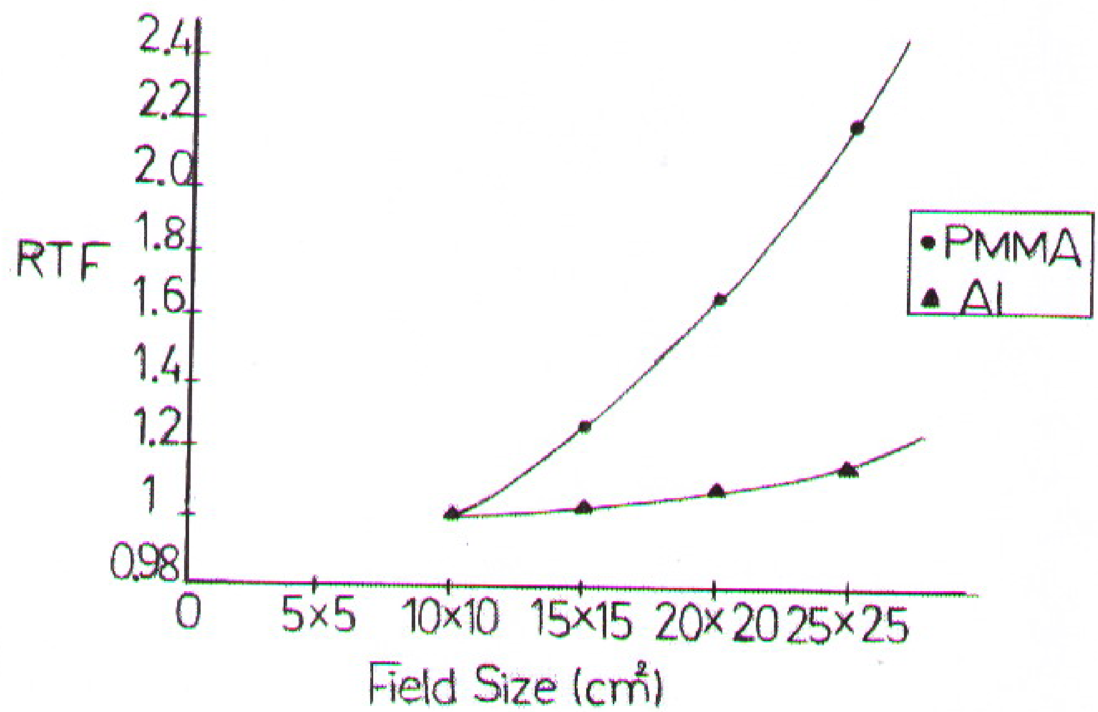

Fig. 2: RTF as a function of field sizes and SSDs for PMMA and Al tray, SSD= 60 cm.

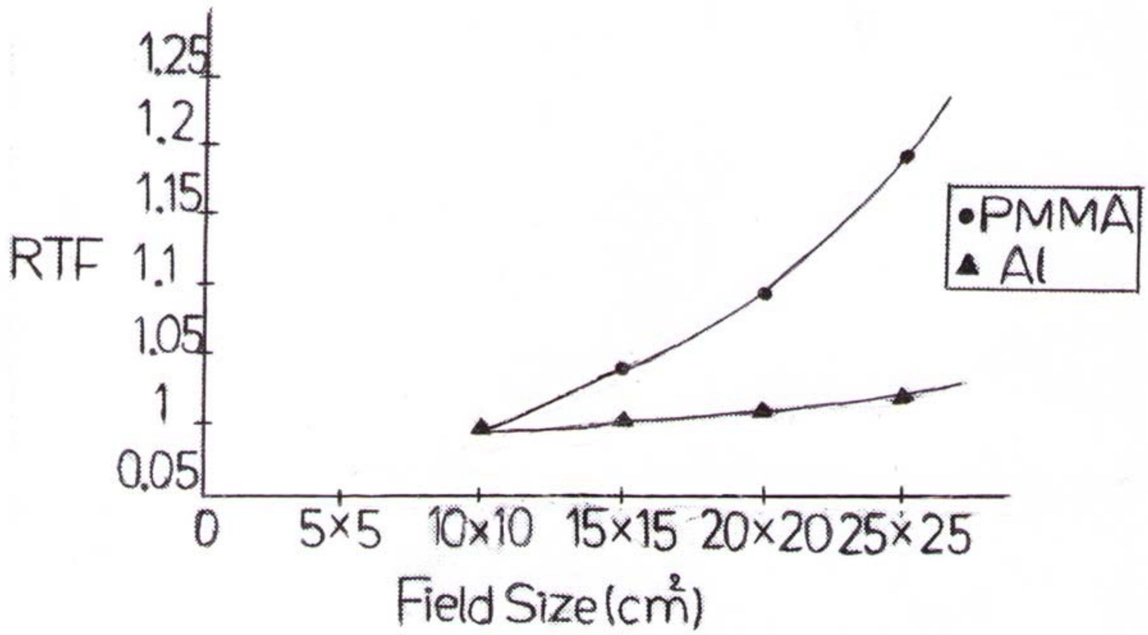

Fig. 3: RTF as a function of field sizes and SSDs for PMMA and Al tray, SSD= 70 cm.

Fig (4) shows the RTF at SSD = 80 cm for the same type of trays. In this figure the RTF increase to (1.032) for Al tray and to (1.081) for PMMA tray when the field size is (25 cm x 25 cm). In all figures the results of RTF for PMMAand Al trays have been compared with each other, the value of RTF for variouses field size and SSDs are shown in Table (1) and Table(2) for both trays.

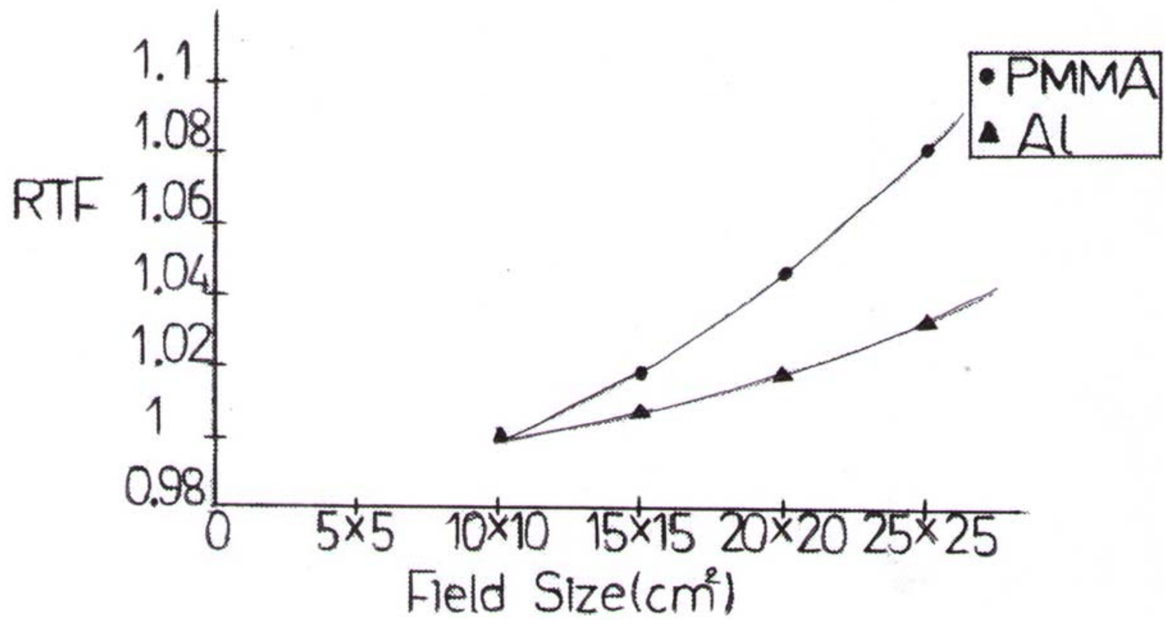

Fig. 4: RTF as a function of field sizes and SSDs for PMMA and Al tray, SSD= 80 cm.

Table 1: The RTF for PMMA tray at different field sizes and SSDs.

SSD (cm)	RTF			
	Field Size			
	10 x 10 (cm^2)	15 x 15(cm^2)	20 x 20(cm^2)	25 x 25(cm^2)
60	1	1.29	1.69	2.22
70	1	1.049	1.11	1.20
80	1	1.019	1.046	1.081

Table 2: The RTF for Al tray at different field sizes and SSDs.

SSD(cm)	RTF			
	Field Size			
	10 x 10(cm^2)	15 x 15(cm^2)	20 x 20(cm^2)	25 x 25(cm^2)
60	1	1.042	1.101	1.176
70	1	1.007	1.017	1.029
80	1	1.0076	1.018	1.032

CONCLUSION

1. Dependence of RTF on Field Size:

The variation of RTF as a function of field size was found that increase with increase of the field size as shown in Figures (2, 3 and 4). This increasing is due to the scatter of the tray, which was a copious source of secondary electrons, generated by the primary radiations. These electrons will be travel in the forward direction so when the field size increases from (10 cm x 10 cm) to (25 cm x 25 cm) this means that the irradiated area of the tray will increases and as result, the RTF increases.

2. Dependence of RTF on Source-Surface Distance (SSD):

We found an opposite correlation between RTF and SSD, this was due to the reduction in the contribution of the total dose from photons which scatter in the tray. At shorter SSD (SSD = 60 cm), the tray was only (7 cm) from the surface, RTF values were increase with a field size larger than (10 cm) as shown in Fig. (2). At larger SSD (SSD = 80 cm), the tray reach to (27 cm) from the surface, RTF value were decreases with a field size larger than (10 cm) as shown in Fig. (4).

3. Dependence of RTF on the Type of The Tray:

Figures (2 ,3 and 4) revealed that the RTF value for PMMA tray is greater than that for Al tray, this may be explained as follows: the interaction of γ-ray with matter depends on the density, the atomic number (z) of the materials (tray), and since all of the electrons grated in this interaction are Compton electrons, the production of Compton electrons is proportional with the number of electrons per gram, that is (N /A)Z, so that the number of electrons per gram for PMMA tray (ź = 6.56) was greater than for Al tray (z = 13), therefore, the RTF value for PMMA tray was larger than that of Al tray.

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