Small Electron Field Surface Dosimetry Using Solid State Detectors

Solid state detectors are excellent clinical dosimeter systems owing to their high sensitivity and quick readout. Typically, these are used for entrance dose measurements on the surface of the patient, perhaps with a build-up cap. This use for small electron fields results in an over-response of the measured dose. This appears to contradict the majority of literature concerning the use of solid state detectors in which output factors are accurately measured[1,2,3], but at a depth of d_{max} or with larger fields (> 4x4 cm^2). We investigate the influence of taking measurements on the patient's surface on measured output factors as compared to measurements taken at some depth in a water-equivalent phantom.

We used two independent systems, a Best-Medical MOSFET Detector system and a Sun Nuclear QED Diode detector system. Both receive routine clinical use for assessing patient dose. The MOSFET system has no intrinsic build-up, so it utilizes a build-up cap sufficient to provide dmax depth when used clinically. This was not used in this study. The diode detector system utilizes no extra build-up, but is designed with an effective depth of 3 mm of water intrinsic to the diode. The MOSFETs were operated in standard sensitivity (~1 mV/cGy) and therefore more accurately reflect the actual dose delivered to the point of measurement. The diode system was used with the normal clinical calibrations which do not accurately convert ionization to dose for all depths and therefore do not accurately measure absolute dose for all depths.

Figure 1 shows the output factor for a 12 MeV beam as a function of the percent of the field blocked and with increasing depth as measured with the diodes. For very small fields, the surface measurements deviate significantly from those taken with an ion chamber during machine commissioning. However, as depth of measurement increases, the measured output factor converges to the accepted value. This trend is representative of most energies. For a 6 MeV beam, the 90% blocked field significantly under-responds relative to commissioning measurements. This may occur because the radiation field is dominated by scatter and as a result has a significantly shallower d_{max} value.

The deviations appear to be more a function of actual field size rather than blocking percentage. Output factors were accurately measured for fields 4x4 cm^2 and larger. For fields smaller than

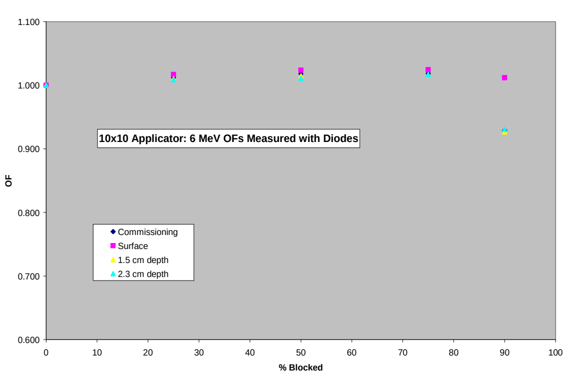

Figure 1: OF measured with Diodes for a 6 MeV beam with a 10x10 cm^2 applicator.

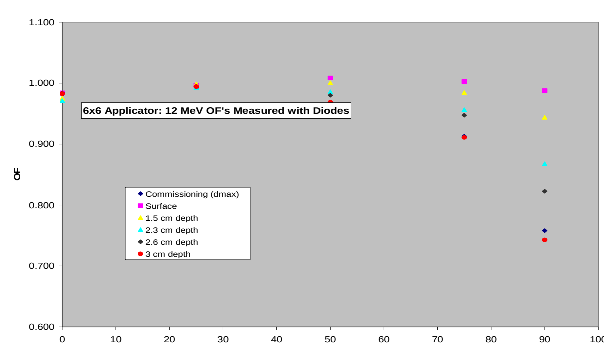

Figure 2: OF measured with Diodes for a 12 MeV beam with a 6x6 cm^2 applicator.

this size, the measured output factors differed by as much as 30%. This can be determined by looking at which fields deviated from expected values. A 10x10 cm^2 applicator that is 75% blocked produces a 5x5 cm^2 field, whereas a 6x6 cm2 applicator that is 75% blocked is 3x3 cm2. The 3x3 cm2 field shows a 9% over-response relative to the accepted output factor for a surface measurement. If the differences were the result of blocking percentage, we would expect the 5x5 cm2 field to show an equally significant deviation. However, we only find a 3% variation, within the limits of measurement tolerance (~ ±5%).

The high sensitivity of these detector systems, which make them so useful, also leads to this artifact. Their non-tissue equivalence makes the response to low-energy scatter much higher than would occur for a tissue-equivalent detector. This is indicated by the much higher deviations for 6 and 12 MeV, whereas the higher energy beam (20 MeV for diodes and 18 MeV for MOSFETs) does not show as significant a deviation, consistent with higher-energy electrons being scattered less than the lower energy components. This also serves as evidence that the differences are not a result of higher bremsstrahlung production by the increased amount of high-Z material in the field, as bremsstrahlung production is more efficient at higher energies. Additionally, this effect is not demonstrated by measurement with extrapolation chamber, supporting that the difference between measurements is a result of the solid state system, not a real effect of the dose distribution.

Future experimental work will focus on the inclusion of more modern dosimeters, including OSLDs and diamond detectors. The near tissue equivalence of OSLDs makes them ideal for surface dosimetry measurements, particularly in the presence of low-energy scatter. Comparisons between diodes and OSLDs have already been done for photon fields, but not electron fields[4]. Diamond detectors are of interest mainly because their applicability to electron measurements has not been well studied, but also because of their low atomic number. In addition, Monte Carlo models to study the ratio of primary to scattered electrons will help to confirm the increased percentage of scattered electrons incident on the detector as a result of the smaller field.

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