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Investigation of Beekley Adhesive Material's Effects on Dose in the Build-Up Region of Megavoltage Photon Beams

Purpose: To investigate the effect that a foam adhesive material developed by Beekley Corporation for use on patient immobilization devices has on percent depth ionization in the build-up region of megavoltage photon beams.

Methods and Materials: Central axis percent depth ionization measurements were made in water-equivalent plastic material in the build-up regions of both 6 and 18 MV photon beams for a foam adhesive material designed by Beekley Corporation.

The linear accelerator used for this testing was a Varian Clinac 2100C. Using a reference field size of 10 x 10 cm (as specified at 100 cm) and a Source to Surface Distance (SSD) of 90 cm, percent depth ionization data were collected for both energies for the following setups:

(1) Open Field
(2) Thermoplastic Mask Material (Unstretched)
(3) Foam Adhesive Material Only (w/ Adhesive Backing)
(4) Foam Adhesive Material w/ Thermoplastic Mask Material (Double-Sided)

Measurements were taken using a Markus parallel plate ionization chamber (PTW N23343-2003) which has an inherent build-up of 1 mm, in a water-equivalent plastic material (Solid Water™). The chamber was initially positioned so that its proximal surface was coincident with the surface of the plastic. A series of ionization measurements were made by stacking increasing thicknesses of plastic on top of the phantom and resetting the SSD to 90 cm.

An initial reference curve was acquired with no material and then repeated with each of the test materials positioned in turn on the surface, on top of the layers of plastic build-up, in the center of the radiation field. Measurements ranged from no additional build-up to a thickness of build-up material which placed the detector just beyond depth of maximum ionization.

Results: Data were collected in the specified setups for 6 and 18 MV photon beams and normalized to the depth of maximum ionization, yielding relative ionization and hence effectively relative dose. Figures 1 & 2 illustrate the results of these measurements. For the 6 MV photon beam, the foam adhesive material increased the relative dose at 1 mm depth[*] from 25.0% (open field) to 38.3%. Data for the 18 MV photon beam showed similar increases, but of somewhat smaller magnitude. The foam adhesive material mounted on both sides of unstretched thermoplastic mask material was shown to have only a 8.1% increase in the relative dose at 1 mm depth. Results of the same tests for the 18 MV photon beam showed a smaller increase of 6.2%.

∗ It is not possible to make direct surface measurements with a parallel plate chamber but the inherent 1 mm build-up of the Markus design provides a reasonable surrogate for the surface dose. If required, the relative dose at the surface can be extrapolated either by applying a fitting function to the measured data or by simple inspection. The difference between the relative dose at 1 mm and at the surface has no practical impact on the conclusions of this work.

Figure-1: 6 MV Percent Depth Ionization

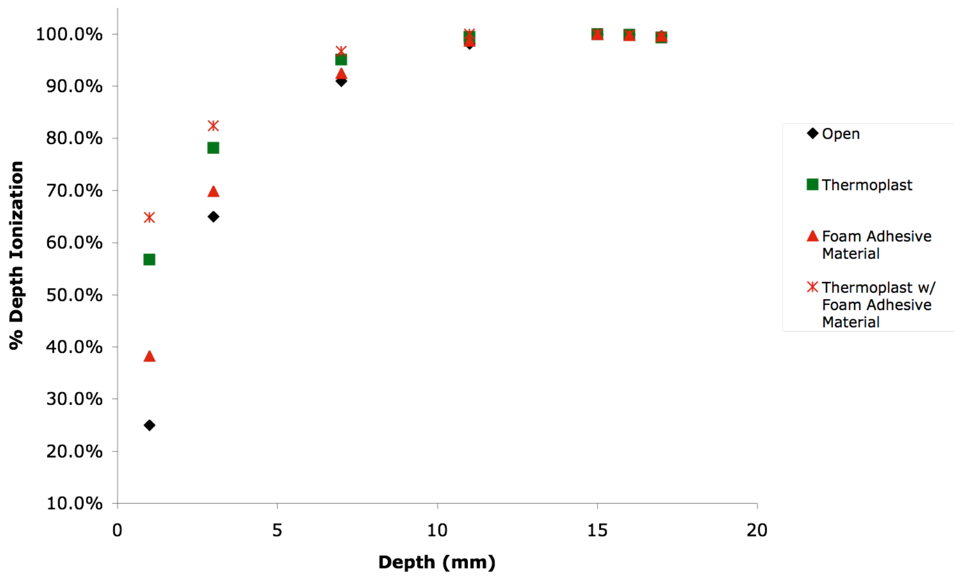
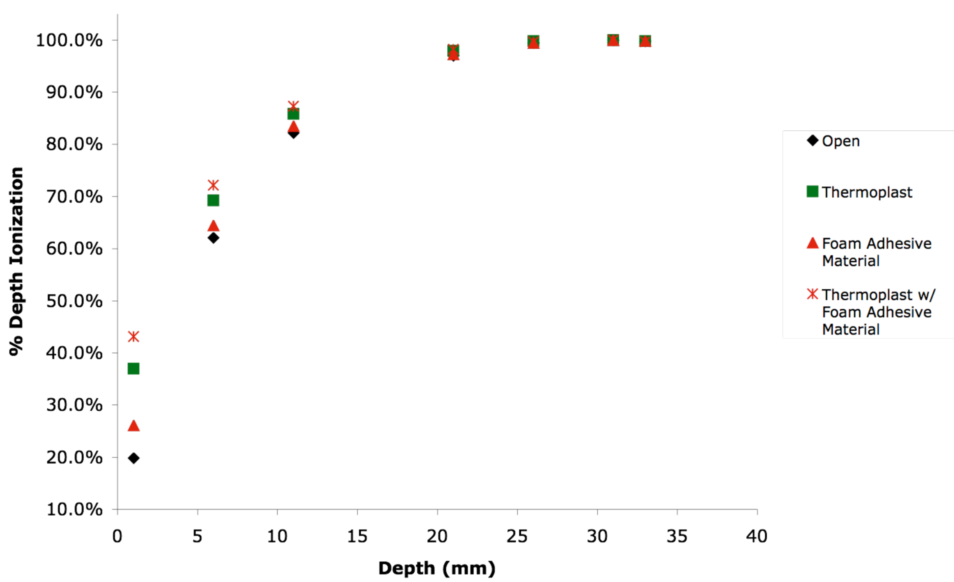


Figure-2: 18 MV Percent Depth Ionization



Conclusion: Our results for the thermoplastic material alone are in good agreement with published data on the effects of a similar thermoplastic material (Fontenla *et.al*. , "Effects of Beam Modifiers and Immobilization Devices on the Dose in the Build-Up Region", Int. J. Radiation Oncology Biol. Phys., 1994). As can be seen in Figures 1 & 2, the effect of the Beekley foam adhesive material is a small incremental increase in surface dose. The effect of the material is significantly less than that due to the thermoplastic material alone. The Beekley foam adhesive material does result in an increase in the 1 mm dose from approximately 25% to approximately 38% in the lower energy (6 MV) photon beam, an absolute increase of about 13% but a relative increase of 52%. This could potentially be of some concern if the material were used alone and the total dose delivered were relatively high, but it is our understanding that this is not the intended clinical scenario.

It should be noted that the setup conditions used in this evaluation would tend to exaggerate the effects of the various materials relative to a typical clinical usage. For instance, the Beekley material samples covered the entire beam rather than a small strip, and the adhesive material was tested with the backing intact. In addition, the thermoplastic mask material was tested unstretched, which presents a thickness greater than would normally be realized in clinical use. Together these effects would be expected to result in an overestimation of the effect of both the thermoplastic and Beekley material, and an underestimate of the relative effect of the Beekley material relative to the thermoplastic. It is our expectation that the magnitude of these approximations is small and they do not influence our current conclusions.

In short, we conclude that the effects on surface dose of the Beekley foam adhesive material is minimal and could be ignored in most clinical situations. In particular, we do not consider the incremental change in surface dose for the Beekley material relative to the effect of the thermoplastic to be clinically significant in most forseeable situations.