A.15: Bremsstrahlung Source Term Measurement for 450MeV Electrons

Bremsstrahlung x-ray source term for an electron accelerator is usually defined as the maximum absorbed dose rate at 1 meter (in a 30 cm diameter sphere made of tissue equivalent materail) per unit electron beam power incident on a high Z thick target. Late W.P.Swanson has compiled the available experimental data on bremsstrahlung source terms in the IAEA technical report series no 188 (1979) and later the same compilation has appeared in the report NCRP-144(2003). Both the compilation indicates that experimental data on bremsstrahlung source term is experimentally available only up to 100 MeV. Beyond this, one either extrapolates the data or depends on Monte-Carlo calculations. At RRCAT, an attempt is made to measure the bremsstrahlung source term at 450 MeV experimentally in the booster synchrotron hall of Indus Accelerator Complex. The source term is also simulated using Monte-Carlo code EGSnrc.

Electron beam at 450 MeV from booster synchrotron is extracted on a lead target (25mm thick) placed just outside an electron exit window in the transport line-2 (TL-2) as shown in Fig. A.15.1.

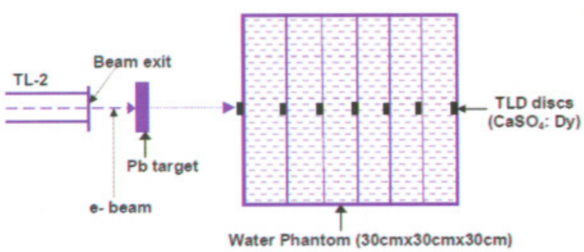

Fig. A.15.1: Schematic diagram of experimental set-up of source term measurement.

A Water phantom of size 30cmx30cmx30cm with $CaSO_4$:Dy TLDs (6.8 mm dia and 1mm thick) at different depths in water is placed 1m away from the target in the forward direction (water phantom is used instead of tissue phantom as for practical applications as human body can be equated to a water phantom). During the experiment the electron beam was allowed to fall at the centre of the target, which was ensured by observing the fluorescence emitted from a ZnS coating provided on the front side of target (with the help of a CCD camera). The number of extracted electrons were obtained from wall current monitor (WCM) located at TL-2 and was found to be 3.26×10^8e/s. After 15min exposure period, the TL discs were removed and read on a TLD reader (RA'94, make: Mikrolab, Poland) to find out the absorbed dose. The absorbed dose profile within the water phantom obtained from the TL data is shown in Fig. A.15.2 (black curve). The maximum dose rate observed is 3.04 Gy/h at 5cm depth within the phantom.

For simulation of the experiment using EGSnrc code, a pencil beam of electrons of 450 MeV was allowed to be incident on 25 mm lead target and absorbed dose per incidence fluence was scored in the TL discs (scoring area 0.363cm^2) placed in different depths of the water phantom. For radiation transport, an electron cut-off (ECUT) of 521 keV and a photon cut-off (PCUT) of 10 keV was used. One million histories were used for the simulation in order to have better statistical accuracy. The obtained statistical accuracy in the present simulation was within ±4%. The results are shown in Fig. A.15.2 (red curve). The Simulated maximum dose rate obtained was 3.10 Gy/h at a depth of 5 cm in the water phantom, in close agreement with the experiment.

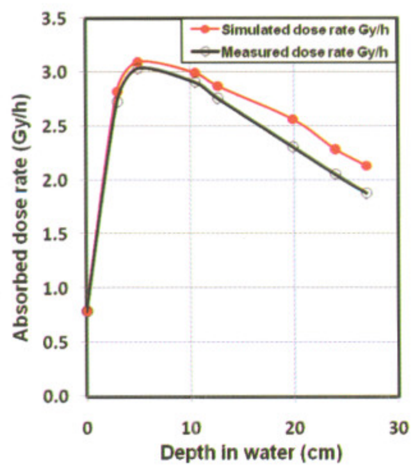

Fig. A.15.2: Experimental and simulated depth dose curves

These results show that the maximum dose rate was obtained at the depth of 5 cm inside the water phantom. Since for the 25 mm lead target, ~4.5 radiation length is used, it is considered to be a high Z thick target and the maximum absorbed dose rate obtained, normalised per unit beam power at 1 meter is the source term. The experimentally measured and simulated source term is shown in Table A.15.1. Both values are in excellent agreement.

Table A.15.1: Source term obtained from experiment and simulation

Estimation techniques	Absorbed dose rate per unit beam power at 1m (Gy/h-kW)
From measurement	1.60×10^5
From simulation	1.63×10^5

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