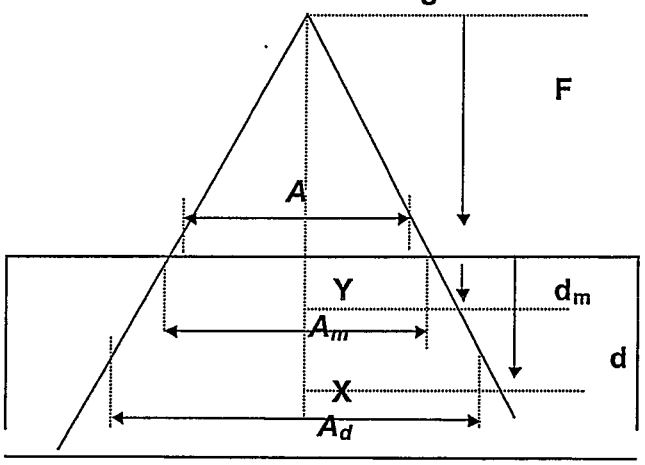
Laboratory Exercise: VIII-4 Measurement of the absorbed dose in the body for a unidirectional exposure to ^{60}Co using a phantom and thermoluminescence dosimetry detectors

Introduction:

For clinical radiotherapy, one is interested in the absorbed dose received by various tissues situated in the irradiated volume. There are various methods described in literature to measure absorbed doses in a phantom at reference point. Functions have been developed to enable one to calculate the dose at any other point once the dose at this reference point is known. Fig 1 shows a beam of radiation incident on the phantom. The size of the beam is specified by stating the dimensions of the field at some specified distance from source.

Fig 1



In the Fig the field has an area A at distance F, or area A_m at distance $F+d_m$ or area A_d at distance F+d. The point Y at depth d_m is the point at which the dose is maximum, while point X is a point at any depth d. For radiation from a 250 kVp deep x-ray therapy machine point Y is on the surface of the phantom. For cobalt radiation of energy 1.25 MeV d_m is at 0.5 cm depth. The depth of dose maximum increases with increase in energy

reaching a value of 5 cm for continuous spectrum with peak energy of 25 MeV in a linear accelerator.

The Central axis percentage depth dose (CADD) is defined as the ratio of the dose Dx measured at point X to the dose Dy measured at point Y both points being within the phantom and along axis of radiation beam. It is expressed as a percentage.

Hence: $CADD (h_v, F, A, d) = Dx / Dy \times 100$

The above equation shows that the percentage depth dose at a point depends on following factors

(1) Energy of Photon Beam 'h_v''
(2) Source to surface distance 'F'
(3) Beam area 'A' at the surface and
(4) Depth of the point in phantom 'd'.

Aim:

To measure depth dose in solid phantom for Co^{60} beam along the central axis of unidirectional radiation beam using TLD detectors.

Apparatus:

Telecobalt unit, mix-D/ perspex sheets 25cm X 25cm , Thermoluminescent dosimeters (TLDs), TLD Reader, and Measuring tape.

Choice of Dosimeter:

Among available TL phosphors, LiF: Mg, Ti, (TLD-100) TL phosphor commercially available with Harshaw - Bicron (USA) is suitable for the measurement of depth doses since it has tissue equivalent properties. LiF:Mg,Ti, extruded ribbons 3.2mm x 3. 2 mm and 0. 9 mm thickness are appropriate for this work.

The dosimetric characteristics of this phosphor are shown in Table I.

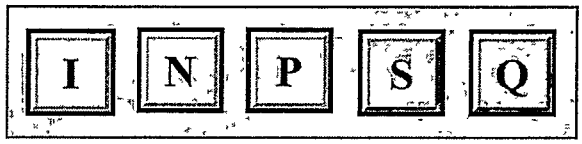


Table I. Dosimetric Characteristics of LiF:Mg,Ti

1. Dosimetric peak temperature	: 195° C
2. TL emission spectrum	: 3500A°-- 6000A°
3 Relative Gamma ray sensitivity at Co-60 relative to LiF	: 1
4. Post irradiation fading of TL response	: 5% in 1 year at 20° C
5. Useful dose range	: 10 μGy - 10 Gy
6. Ratio of TL response at 30 keV /Co-60 gammas	: 1.25
7. Reusability	: Several cycles

Procedure:

First calibrate the Tl reader as given below:

For calibration of the TL Reader Thelmedor, LiF:Mg,Cu,P, ribbons are packed in polythene pouches and exposed to ^{60}Co for range of doses to be used for CADD measurements. For these exposures, a build up of 0.5 cm perspex sheet is placed above the TLD pouches and tissue equivalent phantom (Mix-D, 25 cm x 25 cm x 25 cm) is used as backscattering material. Exposures are also measured simultaneously by a calibrated secondary standard dosimeter (SSD). For this a groove is made in the phantom such that the lower half of the chamber fitted snugly into it and the center of the chamber remained in the plane of surface of the phantom. Observations are recorded in Table II to arrive at the response of TLD ribbons irradiated with Mix-D as backscattering material. A calibration graph can also be plotted using dose (mGy) against TL output (mV) and can be kept for this experiment.

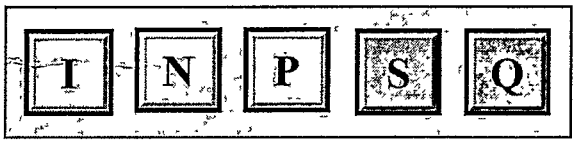


Table - II

Dose meas. (mGy) using SSD	TL Output (mV/)	mV/mGy

1. Use TLD discs and the calibration curve obtained above, for this experiment. 10 pouches, each containing five TLD ribbons are provided. Keep aside one pouch as a control pouch. Use tissue equivalent phantom (Mix-D) for this experiment.

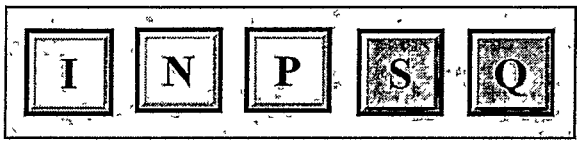
2. At a suitable position in the path of the ^{60}Co beam pile up mix D sheets (phantom) to a thickness of 10 cm. to provide backscatter

3. Keep the pouches one each at the center of the field at depths varying from 0.5cm below surface to 20 cm below surface For identification, give serial numbers to pouches Expose all ten pouches at a time. Use exposure parameters, which are used in actual treatment. Position the top of the phantom set up at the specific source to skin distance of the telecobalt unit. Direct the ^{60}Co beam towards the phantom and restrict the field to 10cm X 10 cm. Enter all parameters in Table No. IV.

4. Measure TL outputs of TLD discs from control pouch and enter in Table No. III Read TL outputs from TLD discs, exposed with phantom, and enter in Table No. IV. Correct these measured outputs of the exposed TLD discs by subtracting average of TL output of control discs from it and enter in Table No IV.

5. Use the calibration curve provided and evaluate radiation doses (Depth doses) corresponding to the TL output. Enter results in Table No.I V.

6. Plot a graph of percentage depth dose versus depth



Observations:

TLD Reader parameters:

Time

EHT : Volts

Heating Temperature : °C

Heating Rate : °C/s

N2 Gas Flushing Rate :

Dark Current :

Table III. **TL Output of Control Ribbons:**

Disc No.	TL Output mV	Average TL Output, mV (A)
1.		
2.		
3.		
4.		
5.		

Table IV

Dose measured at various depths in phantom using TL Discs

Source to skin Distance :--------- cm. Field size: ---------

Av. TL output of Control ribbons from table III (A)----------

Dose at 0.5 cm depth below phantom (Dm) ----------

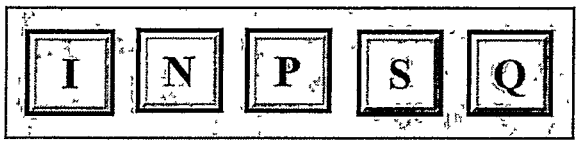
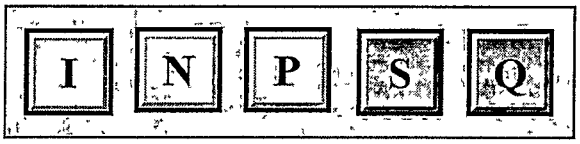


Table-V

Pouch No.	Depth in phantom	TLD Disc No.	TL Output MV (B)	Corrected TL Output mV (B-A)	Average TL Output mV	Radiation Dose from calibration curve (Dx)	% Depth dose Dx/Dm x100
P1	Surface	1 2 3 4 5					
P2	0.5cm	1 2 3 4 5					
P3	1.0cm	1 2 3 4 5					
P4	3cm	1 2 3 4 5					
P5	5cm	1 2 3 4 5					
P6	7cm	1 2 3 4 5					
P7	10cm	1 2 3 4 5					
P8	12cm	1 2 3 4 5					
P9	15cm	1 2 3 4 5					



Results:

Plot a graph of percentage depth dose versus depth.

Observations from the above graph

Depth dose Charecteristics

1. The percentage surface dose : ----------
   (with respect to maximum axial dose)

2 Percentage depth dose at 10 cm depth ----------

Questions:

1. What is reference dose in a phantom and how is it related with dose at some organ in the phantom?
2. How the dose at a reference point in a phantom is measured?
3. What is called depth dose and how it varies with depth in a phantom?

References:

1. The Physics of radiotherapy by Faiz M. Khan, Director Radiation Physics Section, University Hospitals, Minneapolis, Minnesota.
2. Mayneod WV , Lamerton LF : a survey of depth dose data. Br-J Radiol. 14:255, 1944
3. Johns HE , Bruce WR , Reid WB, : The dependence of depth dose on focal skin distance. Br-J Radiol. 31:254,1958
4. Burns JE: Conversion of depth dose from one FSD to another. Br-J Radiol 31:643, 1958
5. H .E. Johns* and J.R. Cunningham, The Physics of Radiology, *Head, Physics Divn, Ontario Cancer Institute, Toronto, Canada.