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Original Article

Installation and Commissioning Experience with a New Generation High-Energy Medical Linear Accelerator with Advanced Delivery and Imaging Functionalities

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Abstract
A High-Energy linear accelerator (Elekta Synergy) was installed during 2010 at Mahavir Cancer Santhan. The first Elekta Synergy, High-Energy linear accelerator was installed at Radiation Oncology Departemnt of Mahavir Cancer Santhan and put into clinical operation in December 2010. The Aim of this study was to report experience about its Commissioning data, beam characteristics and the modeling into the treatment planning system were summarized.
All the commissioning data and quality assurance test have been carried out after the installation of machine. The measurement and observation are within the well tolerance prescribed by the regulatory authority .All data was sending to Atomic Energy Regulatory board for verification. After taking the commission approval from AERB, BARC, All data was entered in treatment planning system by qualified &certified (By Atomic Energy Regulatory Board) Radiological safety Officer of Institute.
Keywords: *Medical Linear Accelerator, PDD Measurement.*

Introduction

A linear accelerator cannot be used for patient treatments until it has been calibrated and all the beam data and necessary parameters for treatment planning have been obtained. These data are then input into a Treatment Planning System (TPS) in accordance with the software requirements. The computer generated dose distributions are checked against measured data[1] .After the necessary beam data have been acquired and adopted to the treatment planning system[2] , the machine can be released or commissioned for clinical use.

The purpose of this paper is to describe the beam data required for TPS (XIO) and quality assurance test recommended by AERB for accurate monitoring and treatment delivery[3].

Materials and Methods

Linear accelerator (Elekta Synergy) with XVI , iViewGT,60˚ motorized wedge , 40 pairs of MLC have two photon energies (6 MV,15 MV) and seven electron energies (4,6,8,10,12,15&18) MeV[4,5].

Following beam commissioning data have been carried out for TPS.

Data & Description

Depth dose

As the beam is incident on a patient, the absorbed dose in the patient varies with depth.

Table-1 In line & Cross Line Measurement

In Line & Crossline	SSD mm	D_{max} %	D_s %	E_0 Mev	E_{po} Mev	R_{100} mm	R_{50} mm	R_p mm	R_q mm	R_{ref} mm
ELETRONS -4MeV										
60mm	1000	100	90.9	2.88	3.64	4.5	12.4	17.2	7.4	6.4
ELETRONS -6MeV										
60mm	1000	100	88.4	4.68	5.45	8.7	20.1	26.3	13.1	11.0
ELETRONS- 8MeV										
60mm	1000	100	90.3	6.27	7.12	12.8	26.9	34.7	19.0	15.2
ELETRONS -10 MeV										
60mm	1000	100	91.8	7.97	8.90	16.5	34.2	43.6	24.7	19.5
ELETRONS -12 MeV										
60mm	1000	100	94.6	9.90	10.94	16.9	42.5	53.8	30.6	24.5
ELETRONS -15 MeV										
60mm	1000	100	97.2	12.54	13.97	11.0	53.8	68.9	38.1	31.3

This variation depends on many conditions like Beam energy, Depth, Field size, Distance from source & beam collimation system. The quantity Percentage depth dose (PDD) is defined as the quotient, of the absorbed dose at any depth to the absorbed dose at a fixed reference depth, along the central axis of the beam[6,7].

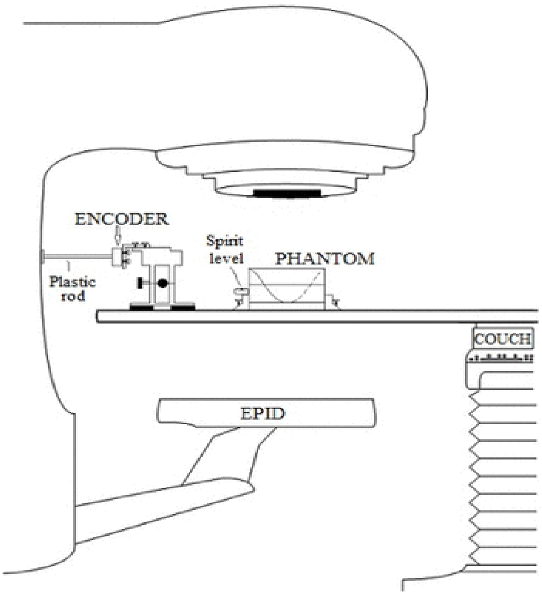

Fig-1 Schematic Diagram of Dosimetric setup

Central axis depth dose for photon energies are measured with 0.125cc ion chamber at 100cm SSD for [2x2,3x3,4x4,5x5,7x7,10x10,12x12, 15x15,20x20,25x25,30x30, 35x35 and 40x40]cm^2 field size, Scan depth: deepest obtainable depth (30cm).[2,8,9]

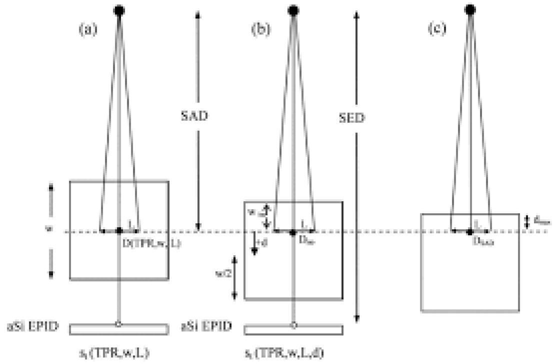

Fig-2- Dosimetric setup for SSD and SAD

Central axis depth dose for all electron energies are measured for each cone at 100 and 110 cm SSD, scan depth: 0 to (R_p + 10 = 20)cm

Profiles:

The representation of the dose variation across the field at a specified depth is known as the beam profile. From beam profile we get [3,4,5]_

Flatness:

For photon beam flatness is calculated by obtaining the Maximum (Mmax) and Minimum (M_{min}) values of dose in the central 80% region of the respective beam profiles. Flatness = (M_{max} – M_{min})/(M_{max}+ M_{min})⁎100 .Tolerance ± 3%. For electron beam flatness specifies in terms of a uniformity index (R). R = L90% /L50% and L90% and L50% are widths of 90% & 50% isodoses[10,11] (Tolerance R ≥ 0.85).

Symmetry:

For photon beam symmetry is the ratio between measured values for each pair of symmetrical points for a range of field size .It must lie between 0.98 and 1.02 within the central 80% flattened beam area. For electron beam symmetry is the ratio of doses at symmetrical points within the area defined by 90% isodose. (Tolerance 2%)

Field size (width at 50%):

Field size defined as the lateral distance between the 50% isodose lines at a reference depth.

Penumbera:

It defined as the distance between the 20% and 80% dose points, measured in the plane containing the isocenter. Tolerance 7mm for field size 5 x 5cm^2 to 15 x 15cm^2 and 8mm for field size greater than 15 x 15cm^2 to 40*40cm^2 at depth of D_{max} .

In-plane and Cross Plane

For photon energies

1. In-plane and cross-plane profile is measured with 0.125cc ion chamber at Depth (Dmax,5,10,20,30) cm for field size [2x2,3x3 ,5x5,10x10, 15x15, 20x20, 25x25, 30x30 ,35x35 and 40x40]cm^2 ,scan limits 6cm outside the field edge [6,7]
2. Diagonal Profile is measured with 0.125cc chamber for largest field size 40*40cm2 at depth (dmax,dmax-0.5, dmax+0.5,0.5,1,2,3,5,10,20,30)cm at 45° degrees diagonal scan

For Electron energies

In-plane and cross-plane profile is measured for each cone at 60 and 100 SSD with depth (d_{max}, d90, d80,d50 and d20).

Output factors:

Output factors are measured at 100 SSD and 10 cm depth for field size (1x1, 2x2,3x3,4x4,5x5, 7x7,10x10,12x12,15x15,20x20,25x25,30x30,35x35,40x40)cm^2 with 0.125cc ion chamber and field size (1x1,2x2,3x3,5x5,10x10) cm2 at 10cm depth with pin point chamber. Then we normalize all measurements to reference field size of 10 x 10 cm^2.

Absolute Dose in water:- Dose rate in CGy/MU for the reference field size (10x10) cm^2 at 100cm SSD and 10 cm depth.

Quality Index

The ratio of the ionization (J_{20}/J_{10}) measured at 20cm and 10cm depth respectively for a field size of 10 x 10 cm^2 at detector level and with a 100 SSD is called quality index. QI is measured for 6 MV and 15MV .Tolerance for 6 MV is 0.676 ± 0.009 and for 15 MV is 0.767 ± 0.005. [8]

Block edge profile:

20x20 cm2 collimator setting, blocked down to a 10 cm wide asymmetric port such that one edge is 7.5 cm from CAX and the other edge is 2.5 cm from CAX. Depth at D_{max},5, 10, 20 & 30 cm.

MLC Edge Profile:

➢ For 3D conventional beam model

20x20 cm2 collimator setting with a 10 cm wide asymmetric MLC port with one leaf bank at 7.5 cm from CAX and other leaf bank at 2.5cm from CAX. Depth - Dmax,5 ,10,20&30 cm with 0.125cc ion chamber[9]

➢ For IMRT beam model

2x10 cm2 MLC shaped field with 0.01cc ion chamber at depth Dmax, 5,10,20&30 cm. Collimator 10x10 cm2 set.

Wedge PDD and Profile:

Wedge PDD and profile along wedge direction (depth of d_{max} 5, 10, 20&30cm) for field size 5x5, 10x10,20x20x30x30 cm2 with 0.125cc chamber are measured.

Wedge factor:

The presence of a wedge filter decreases the output of the machine, which must be taken into account in treatment calculations. This effect is characterized by the wedge factor, defined as the ratio of doses with and without the wedge.

Wedge factors are measured with SSD 100cm and 10 cm depth for field size 5x5,7x7,10x10,12x12, 15x15,20x20,30x30 cm2.

Tray transmission factor: Tray transmission factor is defined as the ratio of doses with and without the tray. Factors are measured at 10 cm depth for 10x10 cm^2 field for each tray. We have done all the quality assurance test (Mechanical, Electrical, dosimetric test and Radiation Survey) according to Atomic energy regulatory Board (AERB) after installation of machine. [10]

Results & Conclusion

All the commissioning data and quality assurance test have been carried out after the installation of machine. The measurement and observation are within the tolerance prescribed by the regulatory authority[12]. All data was sending to Atomic Energy Regulatory board for verification. After taking the commissing approval from AERB, BARC, All data was entered in treatment planning system by qualified &certified (By Atomic Energy Regulatory Board) Radiological safety Officer of Institute.

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