KUBTEC® SCIENTIFIC Tech Notes:

XCELL 180 Percentage Depth Dose (PDD)

Introduction

The percentage depth dose (PDD) is a way to characterize dose penetration on the central axis of an x-ray beam. It is a normalized number expressed as a percentage. Normalized means that all values are expressed with respect to one point—in this case, the point of maximum dose (. The dose acquired at each depth is divided by and multiplied by 100 to produce a percentage (Eq.1). Thus, the PDD is a value, expressed as a percentage, that relates the absorbed dose at any depth in a medium to the maximum measurement on the same central axis.

$$PDD = \frac{d}{d_0} * 100$$

In the case of orthovoltage beams (Xray energy from 100-500kv), the depth of maximum dose is typically the surface. There are four factors that affect the amount of dose that is deposited in a medium: energy, radiation field size, density of medium, and source-to-surface distance (SSD). In this white paper, we acquired PDD curves for an orthovoltage beam of 180 kV at an SSD of 35 cm, with a radiation field size of 4 cm and 9 cm. In other words, energy, medium and SSD remained constant.

Definitions

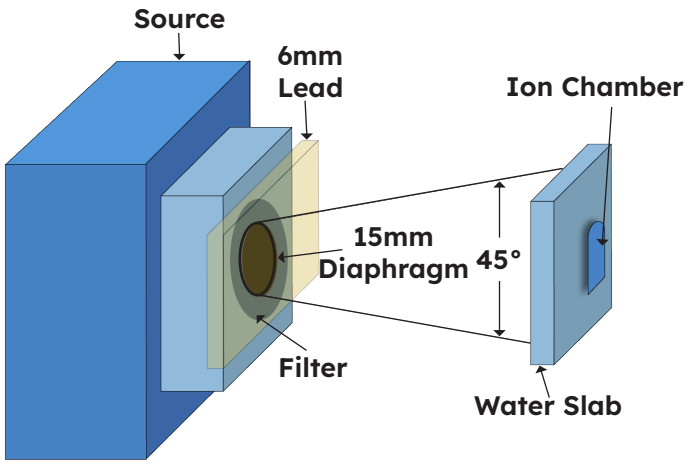
Percentage Depth Dose: The air kerma fraction of an exposure when compared to the initial reference measurement without an attenuator.

Experiment Equipment and Materials

- X-ray source, 180 kV, 1 kW
- 0PTW farmer chamber, model TN30013, serial number 013470
- PTW Unidos Romeo electrometer, model TN10053
- Filters:
  - 0.15 mm Al
  - 1.65 mm Al
  - 0.15 mm Al + 0.25 mm Cu
  - 0.15 mm Al + Thoreaus Filter (1.5 mm Al + 0.25 mm Cu + 0.75 mm Sn)
- Water phantom slabs, one of each: 4 cm, 3 cm and 1 cm. Gammex INC CTG Solid Water Ref 557-30x300c.0 CTFG
- Lead diaphragm to collimate the beam to the reported field size (4 cm and 9 cm).

Experimental Setup

The x-ray source monoblock was set up to produce x-rays horizontally with respect to the floor within a lead room. A 6 mm lead sheet (diaphragm) was installed flush to the exit window of the source. This lead diaphragm had a 15 mm diameter opening in the middle, and with a 45° beam angle, produces a beam diameter of 4 cm at the location of the ionization chamber for the first part of the experiment, and a beam diameter of 9 cm for the second part of the experiment. The filter was installed next to the lead sheet, distal the source.



Dosimetric and radiochromic film tests were performed to ensure that the sensitive area of the ionization chamber was accurately placed within the diameter of the x-ray beam.

During the experiment, the water phantoms were set up to yield an SSD of 8 cm, which remained constant throughout the experiment. The 4-cm water slab was machined to fit the farmer chamber in the middle of it. The sensitive area of the chamber is located 2 cm from the surface of the phantom. Additionally, there are a 3-cm and a 1-cm thick water phantoms. With these 3 phantoms, different configurations were set up that yielded the following depths: 2 cm, 3 cm, 5 cm and 6 cm. Doses were acquired at these depths and at the surface.

Procedure

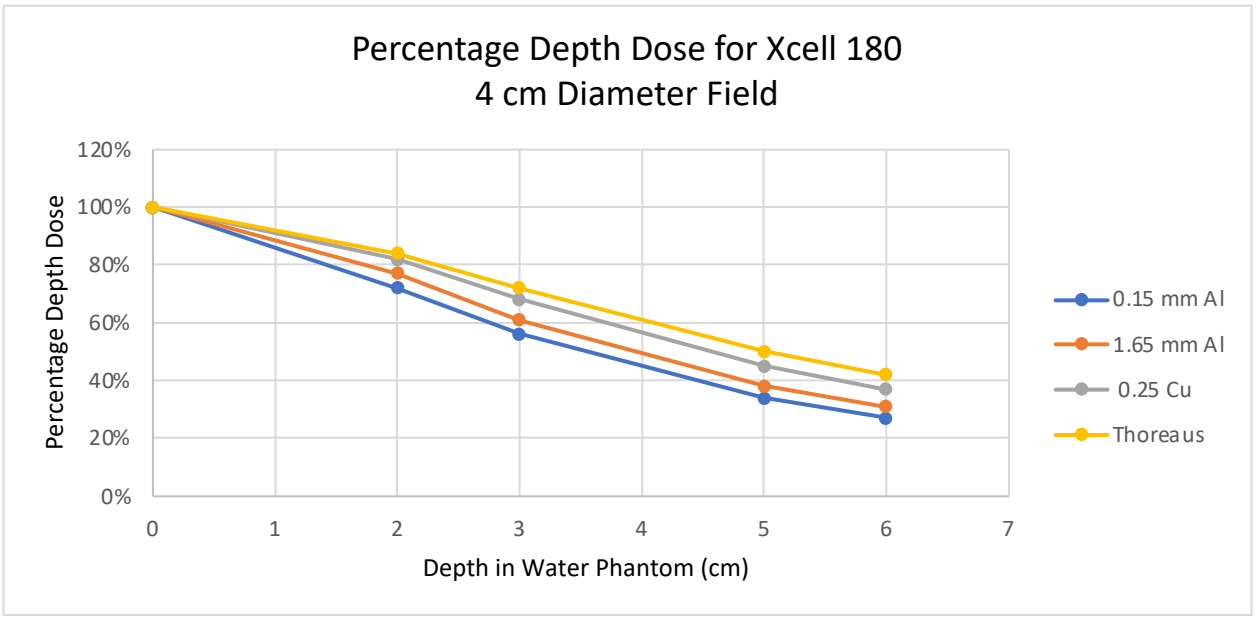
The PDD tests were performed at 180 kV, which is the maximum energy of the x-ray beam of the Xcell 180.

1. The source was warmed up.
2. The electrometer was adjusted for atmospheric pressure and room temperature. This adjustment was performed every 55 minutes.
3. The dose was acquired with each of the water phantom configurations, and the doses were acquired at each depth with each filter.

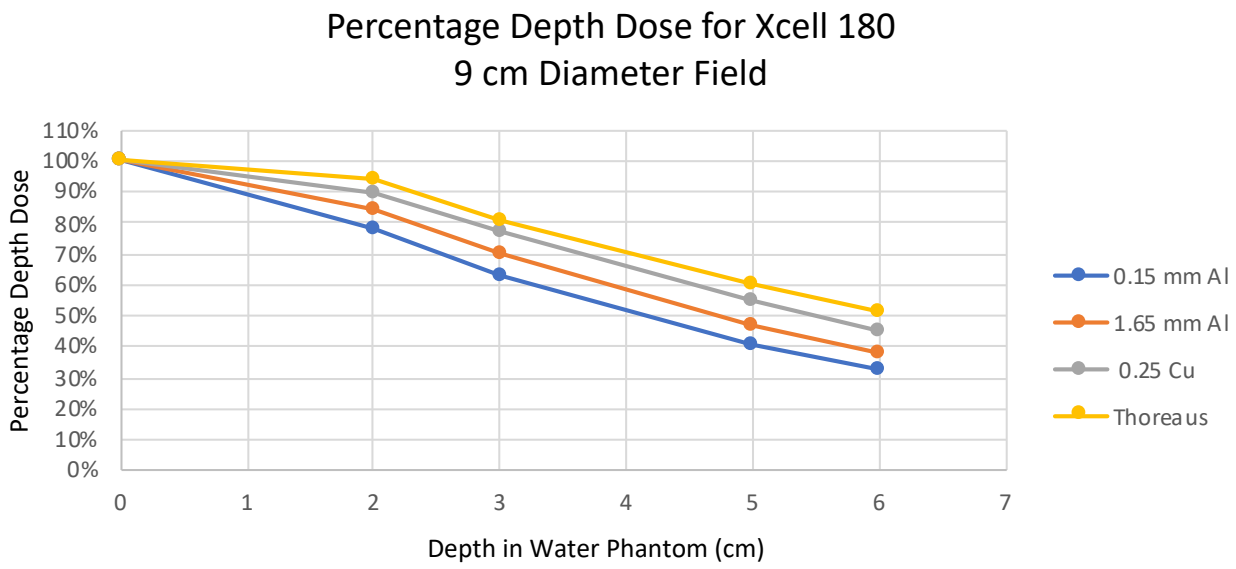
Results

Percentage Depth Dose for 4 cm Field and 9 cm Field:

	PDD for 4cm field				PDD for 9cm field			
Depth	0.15mm Al	1.65mm Al	0.25mm Cu	Thoreaus	0.15mm Al	1.65mm Al	0.25mm Cu	Thoreaus
0	100%	100%	100%	100%	100%	100%	100%	100%
2	72%	77%	82%	84%	78%	84%	90%	94%
3	56%	61%	68%	72%	63%	70%	77%	81%
5	34%	38%	45%	50%	41%	47%	55%	60%
6	27%	31%	37%	42%	33%	38%	45%	51%



KUBTEC® SCIENTIFIC



Conclusions

From the tables in the results section, it can be observed that the increase in size of the radiation field (4cm vs. 9cm) increased PDD. This was expected, and it is due to the increase in scattered radiation, which increases with field size. It can also be observed that the PDD increases as the filter materials increase in atomic number and thickness. The filters have the effect of increasing the mean energy of the beam by attenuating the low energy photons, thus increasing the penetration of the x-rays. It is important to note, however, that the fluence of the beam decreases with higher filtration.

It shall be the responsibility of the user to determine which filter is best suited for their individual experiment's needs.

Bibliography

1. Seuntjens, Jan P. "AAPM TG-61 report on kilovoltage X-ray dosimetry. II. Calibration procedures and correction factors." Proceedings of the 22nd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (Cat. No. 00CH37143). Vol. 3. IEEE, 2000.

2. Godfrey, L. D., et al. "Evaluation of half value layer (HVL) and homogeneity factor (HF) of some hospitals in Zaria environs Kaduna State Nigeria." Journal of Archives of Applied Science Research (AASRC9) (2015): 1-3.

3. Johns, Harold Elford, and John Robert Cunningham. "The physics of radiology." (1983).

4. Quimby, Edith H., and L. D. Marinelli. "The Influence of Filtration on Surface and Depth Intensities of 200 KV X-rays." Radiology 21.1 (1933): 21-29.

5. Oliveira, Paulo Márcio C., et al. "Uniformity and field size of filtered x-ray beams." (2007).