Fundamentals of Radio-physics

First Semester

Expermint -2

Lecture 2: Half Value Layer and Filtration

By

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- **HVL (Half Value Layer):** The amount (**thickness**) of a given shielding material needed to **reduce** the radiation emissivity by one-half its value. The HVL is expressed in units of distance (mm or cm)
- The penetrating ability of the radiation is often described as beam quality.

- **Beam quality specified by :**
  1-HVL(Half value layer)
  2-Filter
- **Contributing factors of HVL**
  1-Beam energy
  2-Thickness
  3-Density of medium
- The HVL is related to the linear attenuation coefficient by following equation

$$\mathbf{HVL = 0.693/\mu}$$

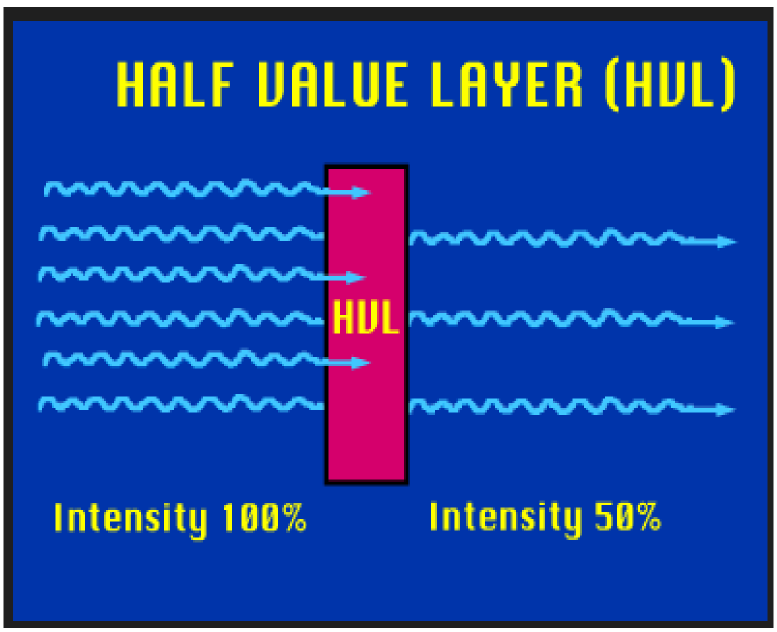

Figure1:

EX: Find the HVL if the linear attenuation coefficient is 0.506 /cm of lead?

$$HVL = 0.693/\mu$$
$$HVL = 0.693/0.506$$
$$HVL = 1.37cm$$

- **Filtration** X-ray imaging systems have metal filters, usually 1 to 5 mm of aluminum (Al). The purpose of these filters is to **reduce the number of low-energy x-rays.**

Low-energy x-rays contribute nothing useful to the image. **They only increase the patient dose unnecessarily because they are absorbed in superficial tissues and do not penetrate to reach the image receptor**.

- **Adding filtration to the useful x-ray beam reduces patient dose.**
- Increasing filtration **increases the quality** of an x-ray beam

Almost any material could serve as an x-ray filter. Al (Z = 13) is chosen because it is **efficient in removing low-energy x-rays through the photoelectric effect and because it is readily available, Lightweight, inexpensive, and easily shaped.**

Copper (Z = 29), tin (Z = 50), gadolinium (Z = 64), and holmium (Z = 67) have been used sparingly in special situations**. As filtration is increased, so is beam quality, but quantity is decreased.**

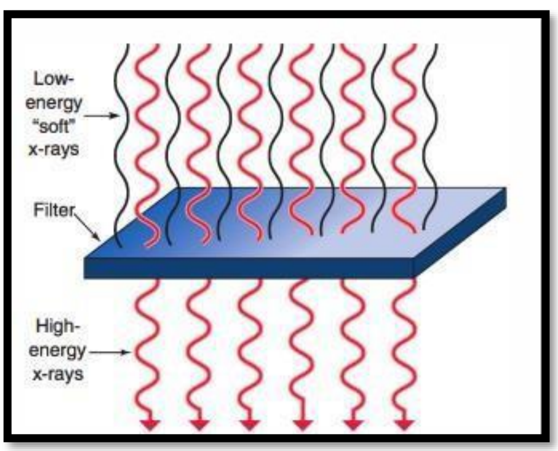

Figure 2:

Effect of Filtration on the Absorbed Dose to the Patient. If adequate filtration were not present, very low energy photons (20 keV or lower) would enter the patient and be almost totally absorbed in the body, thus increasing the patient's radiation dose, especially near or at the surface, but contributing nothing to the image process.

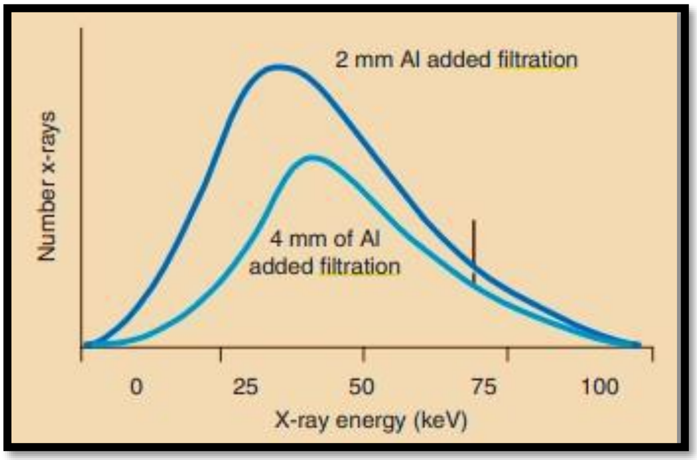

Figure (3):Adding filtration to an x-ray tube results in reduced x-ray intensity but increased effective energy.

Types of Filtration

Filtration of diagnostic x-ray beams has two components: inherent filtration and added filtration.

Inherent filtration: The glass or metal enclosure of an x-ray tube filters the emitted x-ray beam.

The inherent filtration of a general purpose x-ray tube is approximately 0.5 mm Al equivalent.

 With age, inherent filtration tends to increase because some of the tungsten metal of both the target and filament is vaporized and is deposited on the inside of the window.

Added Filtration: A thin sheet of Al positioned between the protective x-ray tube housing and the x-ray beam collimator is the usual form of added filtration.

 The addition of a filter to an x-ray beam attenuates x-rays of all energies emitted, but it attenuates a greater number of low-energy x-rays than high- energy x-rays. This shifts the x-ray emission spectrum to the high energy side,

- resulting in an x-ray beam with higher energy, greater penetrability, and better quality.

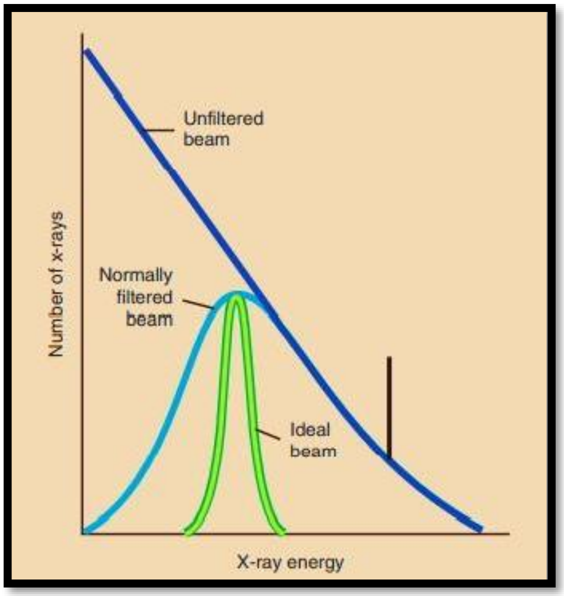

Figure4: Filtration is used selectively to remove low energy x-rays from the useful beam. Ideal filtration would remove all low-energy x-rays.

 Added filtration usually has two sources. First, 1-mm or more sheets of Al are permanently installed in the port of the x-ray tube housing between the housing and the collimator.

 With a conventional light-localizing variable-aperture collimator, the collimator contributes an additional 1 mm Al equivalent added filtration (figure4). This filtration results from the silver surface of the mirror in the collimator

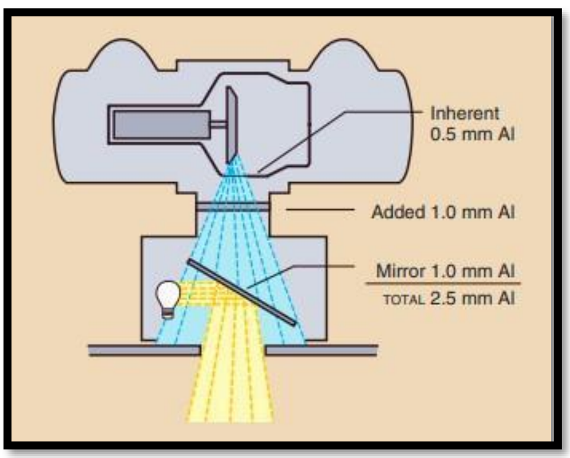

Figure4: Total filtration consists of the inherent filtration of the x-ray tube, an added filter, and filtration achieved by the mirror of the light-localizing collimator.