SNS COLLEGE OF ALLIED HEALTH SCIENCES- COIMBATORE 35

DEPARTMENT : RADIOGRAPHY AND IMAGNG TECHNOLOGY

SUBJECT : GENERAL PHYSICS, RADIATION PHYSICS AND PHYSICS OF DIAGNOSTIC RADIOLOGY

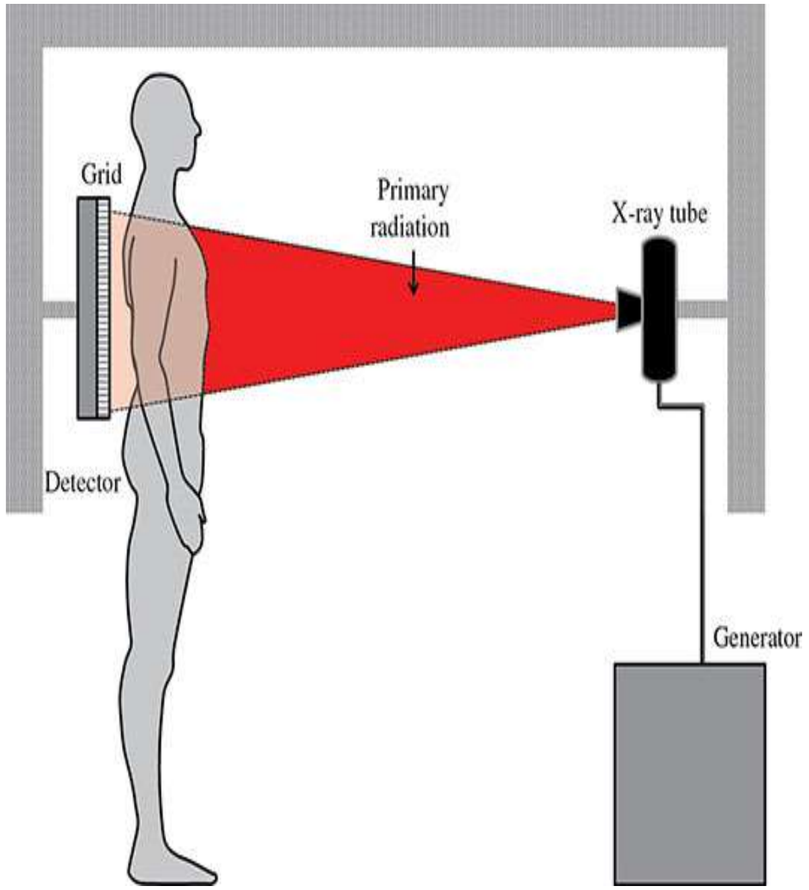
PAPER : PAPER II (UNIT 5 – PHYSICS OF DIAGNOSTIC RADIOLOGY : X-ray TUBE)

TOPIC : 3. X-ray BEAM QUALITY

QUALITY AND INTENSITY OF X-rays

QUALITY

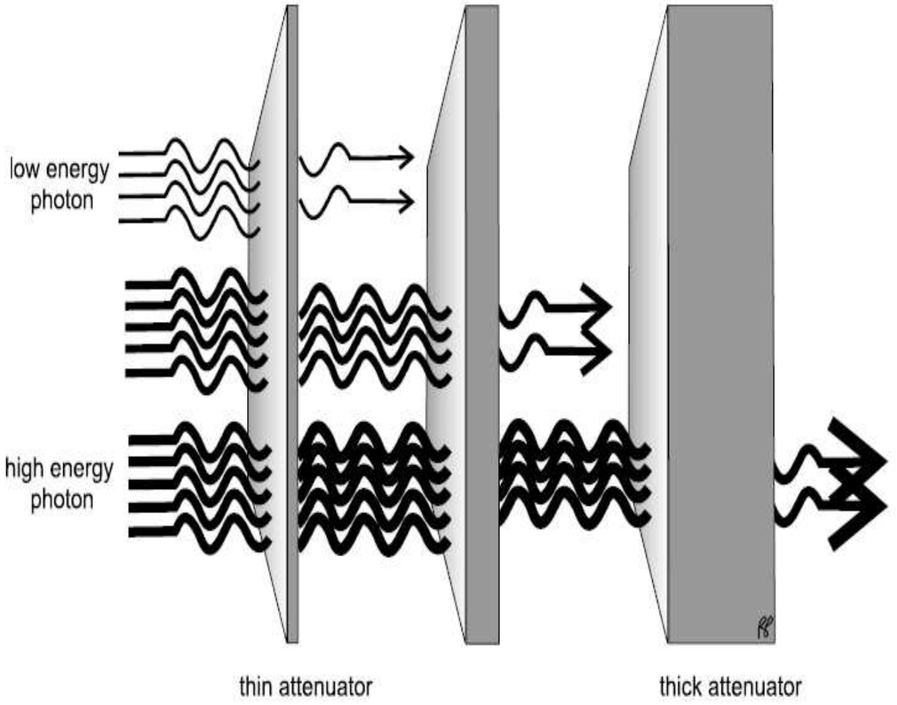
- The term quality describes the penetrating power of the radiation.
- It a radiation consist photons of single energy (mono-energitic), then the quality can be described either by photon energy or wavelength.
- But, X-ray beam consist many photon energies (heterogeneous), and hence, its quality cannot be described by the photon energy.
- Therefore, the X-ray beam quality is usually specified by the following, half-value layer, applied voltage (KV), filtration and effective photon energy.



QUALITY AND INTENSITY OF X-rays

HALF-VALUE LAYER (HVL)

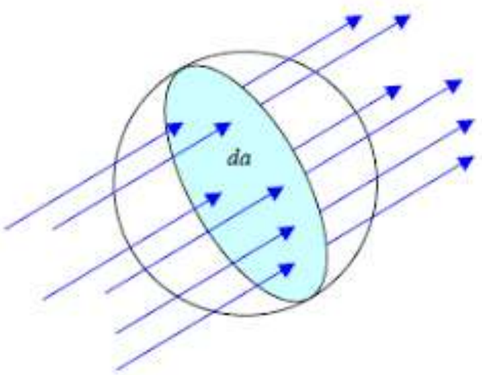
- The half-value layer or half-value thickness of a radiation beam is the required thickness of a material, which reduces the beam intensity to one half.
- The half-value layer is always stated together with the value of the applied voltage and the filtration. Aluminum and copper are the materials commonly used to specify HVL.



QUALITY AND INTENSITY OF X-rays

INTENSITY

- **The intensity is a measure of quantity of radiation. The intensity of a radiation beam is the energy flowing in unit time through a unit area.** It is equal to the number of photons in the beam multiplied by the energy of each photon.
- The intensity is commonly measured in roentgens per minute (R/min).
- The term exposure is often used in radiology, which is proportional to the energy fluence of the X-ray beam. It refers both quality and quantity of the beam.
- The term quantity refers the number of X-ray photons in the beam.



FACTORS AFFECTING QUALITY AND INTENSITY

- The X-ray production efficiency, quality, quantity and intensity are affected by seven factors, namely,
- Applied voltage,
- Tube current,
- Filtration,
- Target material,
- Exposure time,
- Generator waveform and distance.

FACTORS AFFECTING QUALITY AND INTENSITY

The Applied Voltage (kVp)

- The applied voltage affects both the quality and intensity of the X-rays. The energy of the photon emitted from the X-ray tube depends on the energy of the electrons that bombard the target.
- The energy of the electron is, in turn, determined by the peak kilovoltage used. As the applied voltage increases, the effective photon energy in the bremsstrahlung also increases.
- The maximum photon energy is proportional to the peak value of the applied voltage.
- In addition, the X-ray production efficiency is related with applied voltage.
- The intensity increases with increase of applied voltage. The amount of radiation produced increases as the square of the kilovoltage.
- Radiation exposure α kVp^2 Thus, increase in kVp increases the quality, quantity and efficiency of X-ray production.

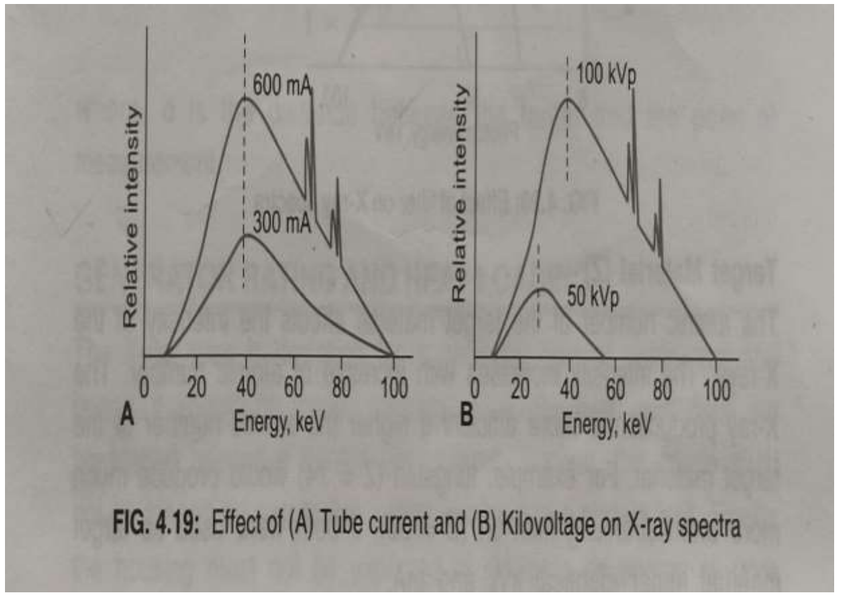


FIG. 4.19: Effect of (A) Tube current and (B) Kilovoltage on X-ray spectra

FACTORS AFFECTING QUALITY AND INTENSITY

TUBE CURRENT (mA)

- The number of X-rays produced depends on the number of electrons that strike the target of the X-ray tube.
- The number of electrons depends directly on the tube current (mA) used.
- Greater the mA, higher the electrons that are produced, and hence, more X-rays will be obtained.
- The tube current affects only the intensity but not the quality of the X-rays.
- As the tube current increases the intensity also increases.
- **Intensity is α mA**

FACTORS AFFECTING QUALITY AND INTENSITY

FILTRATION

- Filters are thin sheet of material (Al, Cu, Mo), which offer high attenuation for low energy photons.
- The purpose of using filter is to reduce patient exposure at the skin level. Filters alter both the quality and quantity of X-rays by selectively removing the low energy photons in the spectrum.
- This reduces the photon number (quantity) and shifts the average energy to higher values by increasing the quality. A filtered beam consists of higher photon energies and is said to be hardened

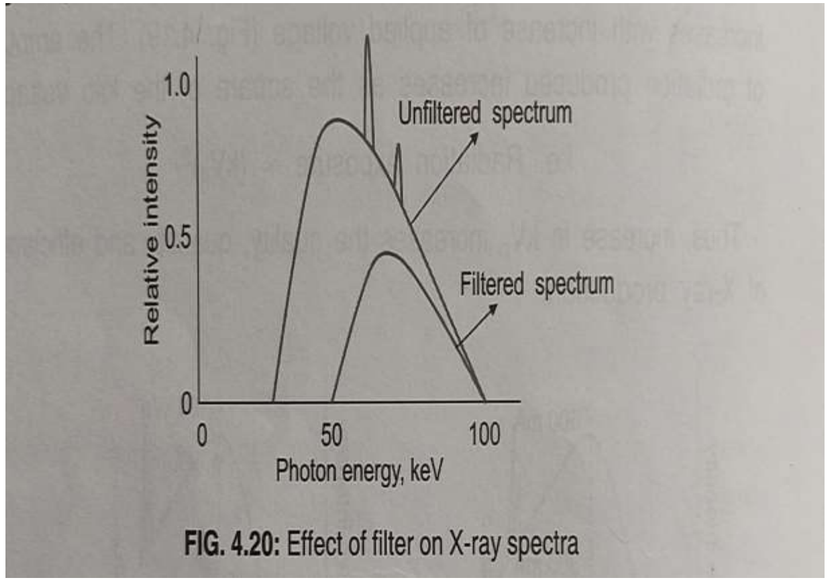


FIG. 4.20: Effect of filter on X-ray spectra

FACTORS AFFECTING QUALITY AND INTENSITY

TARGET MATERIAL (Z)

- The atomic number of the target material affects the intensity of the X-rays. The intensity increases with increase of atomic number.
- The X-ray production is more efficient if higher the atomic number of the target material.
- For example, tungsten (Z= 74) would produce much more bremsstrahlung than tin (Z = 50), if both were used as target material under identical kV, and mA.
- The atomic number of the target material also determines the energy (quality) of characteristic X-rays.
- Thus, the atomic number of the target material determines the intensity of bremsstrahlung and quality of characteristic X-rays produced.

FACTORS AFFECTING QUALITY AND INTENSITY

EXPOSURE TIME

- Exposure time determines the length of X-ray production. The total quantity of X-rays is directly proportional to the product of the tube current and exposure time (mAs).

THE GENERATOR WAVEFORM

- The generator wave form (single-phase, 3-phase or constant potential) directly affects the quality of the emitted X-ray spectrum because of the average potential difference across the tube.
- For example, a single phase generator provides a lower average applied voltage potential difference, than a 3-phase generator.

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DISTANCE

- The X-ray beam intensity decreases with distance from the target because of the divergence of the X-ray beam. The decrease in intensity is proportional to the square of the distance from the target.
- The nonlinear fall-off in intensity with distance is called the inverse square law.

INTERROGATIONS

1. What is Quality of X-ray beam ?
2. What is intensity ?
3. Explain Inverse square law.

INTERROGATIONS

1. What is Attenuation ?
2. What is Absorption ?
3. What is Scattering ?

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THANK YOU