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**X – Ray beam shape and position**

**Generation of x – ray:-**

X – ray photons generate at the surface and within the tungsten button (target) of the anode by bombardment of anode with electrons coming from cathode when the filament is heated electrically.

The speed of these electrons depend on the potential difference (kV) between cathode and anode of the tube.

Electrons impact on (a rectangular area) at the surface of tungsten button of the anode called (focal spot)

Now the kinetic energy of these electrons will converted to X – radiation and heat in fact there is only 0.2% of this energy will converted to X – ray while the remaining energy goes in form of heat this heat will dissipated with the aid of radiator that attach to the anode.

**Focal spot:** - it’s a small area on the tungsten surface (target) on which electrons come from cathode are impacted and X – ray photons are produced. Therefore useful X – ray beam emerges from this spot the rectangular focal spot called (actual focal spot) while the projection of this spot when viewed from any point with the X – ray beam appears more or less like a square this square projection called (effective focal spot).



In diagnostic radiography the use of rectangular focal spot which is projected as a square called (Benosn Line focus principle) this will obtained by setting the surface of the target at an appropriate angle (15 – 20)˚ to the cathode.

This principle help to get these benefits:-

1.X – Ray generated over large surface area on the target .

dissipation of heat 2.Larger actual focal spot for better

**Energy conversion to x – ray:-**

X – ray photons result from conversion of kinetic energy of cathode electrons into X – ray photon energy, and this basically accomplished by 2 ways:-

**First:-**

Electrons can be brought to stop on the surface of the anode (target) through collision with tungsten atoms of the target giving up all of their kinetic energy to X – ray photons such photons will be of high energy (short wave length photons).

Some of cathode electrons giving up only part of their energy and the resultant X – ray photons have low energy (long wave length photons) and most of X – ray photons are created by this manner.

**Second:-**

When cathode electrons able to dislodge one or more orbital electrons of tungsten atom. For example cathode electron must posses more than 69,000 electron volts to dislodge K orbital electron of tungsten atom and this is only occurred when X – ray machine set at 70 Kilovolts or more. Then after the dislodgment of K electron from its shell an electron from L shell falls into the empty place of K shell this will cause a production of specific type of x-radiation with specific energies called characteristic radiation .

**Central ray:** - in the beam X – ray photons that traveling in very center of the cone of radiation, called [central ray] and this is commonly used to fix and locate the position of X – ray beam.

**Inverse square law:-** the low stated that (the intensity of radiation inversely proportional with the square of distance measured from the source of radiation to the point of measuring )

**Rectification:-**

The main supply to the X – ray machine of 240 volts has 2 functions:-

A – Generate the high potential difference (kV) to accelerate the electrons across the x – ray tube via the step up transformer.

B – Provide the low – voltage current to heat the filament via the step – down transformer.

However, the incoming 240 volts is an alternating current with typical wave form as shown:-

Half of cycle is (+) and other half is (-) but for production of X – ray only the positive half of the cycle can be used to ensure that the electrons from the cathode filament are always drawn towards the anode target.

Thus, the stepped – up high voltage applied across the X – ray tube needs to be rectified to eliminate the negative half of the cycle.

Note: x-ray machine is self-rectified.

**Voltage**

**+**

**-**

**Filtration:-** X – ray used in dentistry must be able to penetrate dental hard tissues (teeth and bone). The longer wave length x-ray (soft X– ray) are not useful in diagnostic radiology thus removal of these long wave length photons from the beam by passing the beam through a filter made from (Aluminum), this filter either built into the X-ray machine by manufacturer or added as an extra filter.

The effect of filtration on x – ray beam is absorption of most of long wave length photons (soft X – ray) so the resulting x – ray beam will consist of mainly X – ray photons of short wave length with high energy photons and high penetrating power that’s why they named (hard X – ray beam).

**Collimation:-**

Is a process refers to control of size and shape of X – ray beam. In diagnostic radiography its essential to get the diameter of circular X – ray beam at patients skin surface is not great than 2.75 inches, while for rectangular X – ray beam the dimensions at the skin should be approximately 1½ × 2 inches.

Collimation can achieve by one of 2 methods:-

1.Using diaphragms (round or rectangular shape).

2.Using metal cylinders, cones and rectangular tubes

Diaphragm:- Consists of a metal plate or disk made from lead. A hole is present in the center of the disk allow the beam to pass through it only.

The shape of X – ray beam determine by the shape of the hole of diaphragm such diaphragm is placed over the opening in the head of X – ray machine.

**X – Ray spectrum:-**

X– Ray beam consist of many photons of different wave length because.

A - Electrons don’t give up all their kinetic energy in identical fashion.

B – Potential voltage across the X– ray tube changes constantly as the AC voltage varies to DC, that’s why X – ray beam is poly- different wavelength.

**Definition of terms used in X – ray interaction:-**

**Scattering: -** change in direction of photon with or without a loss of energy.

**Absorption:** - deposition of energy i.e. removal of energy from the beam.

**Attenuation:** - reduction in the intensity of X– ray beam caused by absorption and scattering attenuation = absorption + scattering.

**Ionization:** - removal of an electron from neutral atom.

Absorption of x – ray (interaction with matter):-

**X–Ray are absorbed by any form of matter (solid, liquid, and gas) when photons reach an atom, 4things can happen:-**

1. X – Ray photons can pass through the atom without change occurred to either.

2. It can be deviated from its direction by the atom so the x – ray photon after deviation becomes a photon of scattered radiation.

3. X – Ray photon interacts with inner – shell electron of the tissues atom where the X – ray photon disappears and deposits all its energy this process is pure absorption. Now the inner – shell electron is ejected with considerable energy (now called ( a photo – electron) into the tissue for further interaction with other electrons of other tissue atoms. So this high – energy ejected photo electron be haves like the original high energy X – ray photons interact and eject other electrons as it passes through the tissues, these ejected electrons that are responsible for the majority of ionization , interactions within the tissue and the possible resulting damage attributable to the X– rays.

4.When the X – ray photon interacts with free or loosely bond

outer shell electron of tissue atom, so the electron is ejected (called Compton recoil electron) with some energy from the X – ray photon i.e. there is some absorption and this ejected electron undergoes further ionization interaction within the tissue.

While the remainder of X – ray photon energy is scattered from its original path as scattered X– ray photon.

**Incoming x – ray photon**

**Time**

**Photon completely scatter with no loss energy**

**photon**

**Photon scatter with some loss of energy**

**Photon transmitted unchanged**

**Photon totally absorbed**

**Primary radiation:-** radiation emerging from the x – ray machine in form of collimated useful X – ray beam

**Secondary radiation:-** radiation result from interaction of primary beam with matter

**Half – value layer:-** it’s a method of monitoring the penetration quality of the X – ray beam. Determination of half – value layer is done by placing thin filtering material such as aluminum filter in front of the beam so we continue increase the thickness of filtering material until we have a thickness that reduce the number of X– ray photons in the beam passing through it to (one half) this will representing a half – value layer for such beam of radiation.

High half value layer the high penetrating ability of the beam. In oral diagnosis the acceptable value is approximately 2 mm of aluminum