Radiological Equipment Techniques (Lec 2)

X-Ray Tube

1- Introduction

The x-ray tube is the most important part of the x-ray machine because the tube is where the x-rays are produced.

Radiographers must understand the construction and operation of an x-ray tube.

The radiographer controls many radiographic factors (exposure factors) within x-ray tube such as; Kilovoltage peak (kVp), milliamperage (mA), and exposure time (s).

The radiographer also needs to be aware of the amount of heat produced during x-ray production because excessive heat can damage the tube.

2- The External Structure of the X-Ray Tube Consists of Three Parts:

- The support structure
- The glass or metal enclosure
- The protective housing

2-1- The support structure or support system

The x-ray tube and housing assembly are quite heavy; therefore, they require a support mechanism so the radiologic technologist can position them.

Figure 1: Three methods of supporting an x-ray tube. A, Ceiling support. B, Floor support. C, C-arm support

2-2 The glass or metal enclosure

The entire cathode assembly and all of the anode assembly except the stator is enclosed within a glass or metal envelope commonly called the tube.

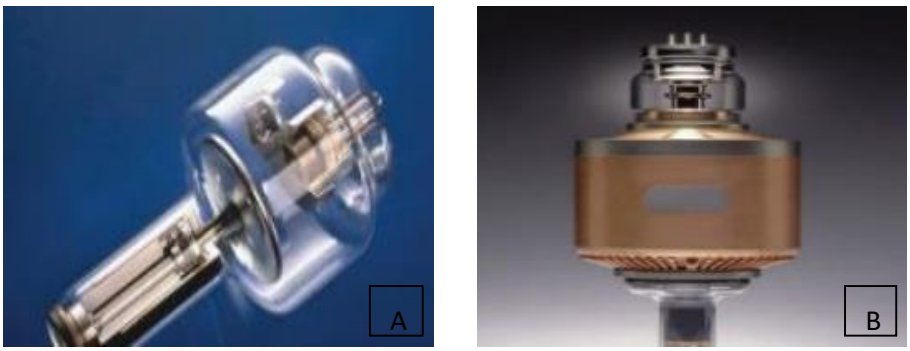

Figure 2: (A) Glass envelope. (B) Metal envelope

- Metal envelopes are increasingly becoming more common. They prolong tube life because they eliminate the problem of tungsten vaporization
- The primary function of the envelope is to maintain the vacuum between the cathode and anode.

2-3 The protective Housing

Modern x-ray tubes must be mounted inside a protective housing. The housing controls leakage and scatter radiation, isolates the high voltages, and provides a means to cool the tube.

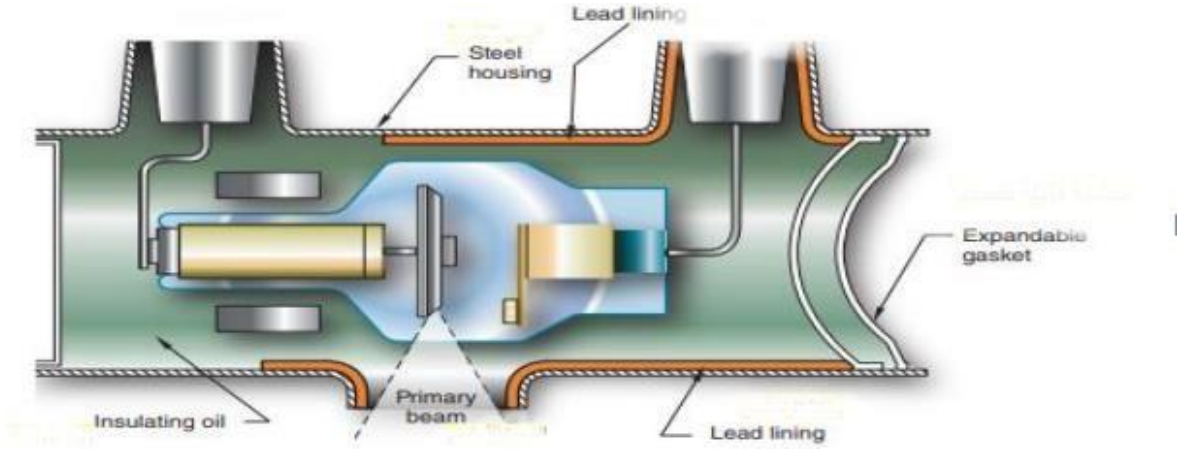

Figure 3: A diagnostic x-ray tube housing

3- The Internal Structures of the X-Ray Tube Are

- The anode
- The cathode

3-1 Cathode

The cathode is the negative side of the x-ray tube; it has two primary parts, a filament and a focusing cup. shows a double-filament cathode surrounded by a focusing cup (Its purpose is to focus the stream of electrons.). The filament is a coiled tungsten wire, which is the source of electrons during x-ray production. Most x-ray tubes are referred to as dual-focus tubes because they have two filaments: one large and one small.

3-2 Anode

The anode is the positive side of the x-ray tube; it conducts electricity and radiates heat and x-rays from the target. The target is the part of the anode that is struck by the focused stream of electrons coming from the cathode. The target stops the electrons and allowing the production of x-rays. The anode composed of tungsten, because tungsten has a high atomic number (74) and a high melting point (3,400°C), it efficiently produces x-rays.

Types of anode

There are two types of anodes:

1. Stationary

2. Rotating

Tubes with rotating targets are more common than tubes with stationary ones, because rotating anodes can withstand higher heat loads than stationary anodes when the rotation causes a greater area, or focal track.

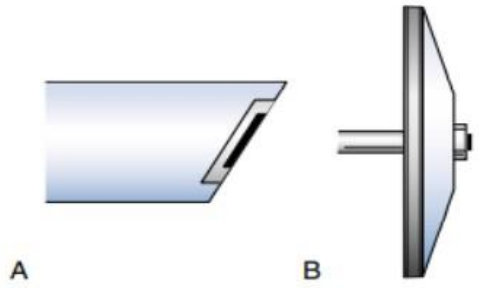

Figure 4: (A) stationary anode (B) and a rotating anode

The rotating anode consists of;

1-target

2-a stator (stator is an electric motor) and rotor

In order to turn the anode during x-ray production. Rotating anodes are manufactured to rotate at a set speed ranging from 3000 to 10,000 rounds per minute (rpm).

The target is a metal that abruptly decelerates and stops electrons in the tube current, allowing the production of x-rays. The target of the rotating anode tubes is made of a tungsten (90%) and rhenium (10%) alloy.

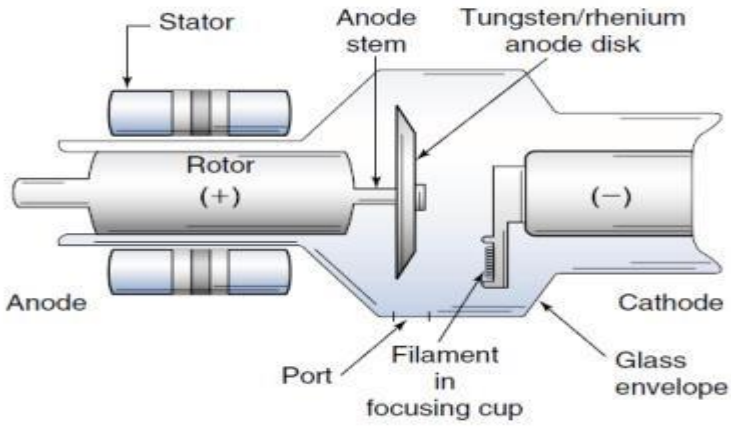

Figure 5: Show the consists of anode

4- X-ray Production

1. The electrons are emitted from a filament in the cathode. Emission occurs when the filament is heated by passing a current through it.

2. The electrons that move from the cathode to the anode travel extremely fast, approximately at half the speed of light. The moving electrons, which have kinetic energy, strike the target and interact with the tungsten atoms in the anode to produce x-rays.

3. Electrons are accelerated by a voltage difference applied from the cathode to the anode. This voltage is supplied by a generator (more than 5KV).

4. The electron from the cathode interacts with the orbital electrons or the nuclear field of target atoms. These interactions result in the conversion of electron kinetic energy into thermal energy (heat) and electromagnetic energy in the form of infrared radiation (also heat) and x-rays.

5- A small percentage is converted to x-rays by two main methods:

1. Bremsstrahlung Interactions

Bremsstrahlung is a German word meaning "**braking**" or "**slowing down**" radiation. Bremsstrahlung interactions occur when a projectile electron is slowed by the nuclear field (very strong electrostatic force) of a target atom nucleus. As the electron loses energy, it suddenly changes its direction, and the energy loss then reappears as an x-ray photon. Most x-ray interactions in the diagnostic energy range are bremsstrahlung.

2. Characteristic Interactions

Characteristic interactions are produced when a projectile electron interacts with an electron from the inner shell (K-shell) of a tungsten atom. The electron must have enough energy to eject the K-shell electron from its orbit. Projectile electron, it must possess energy equal to or greater than 69.5 keV. When the K-shell electron is ejected from its orbit, an outer-shell electron drops into the open position and creates an energy difference.

The energy difference is emitted as an x-ray photon. These interactions are termed characteristic x-rays because their energies are characteristic of the tungsten target element.