X-RAY TUBE FAILURE

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Outline

X-RAY TUBE FAILURE:

- Causes of x-ray tube failure
- Results
- remedy

Objectives

The student should be able to do the followings;

- Identify the three causes of x-ray tube failure.
- Differentiate between the three causes of x-ray tube failure
- Explain the result of each of the three causes of x-ray tube failure
- Analyze how to remedy x-ray tube from failure

X-RAY TUBE FAILURE

With careful use, x-ray tubes can provide many years of service. With inconsiderate use, x-ray tube life may be shortened. The length of x-ray tube life is primarily under the control of radiologic technologists. Basically, x-ray tube life is extended by using the minimum radiographic factors of mA, kVp, and exposure time that are appropriate for each examination. The use of faster image receptors results in longer tube life. Maximum radiographic techniques should never be applied to a cold anode. During exposures lasting 1 to 3 s, the temperature of the anode may be sufficient to cause it to glow like an incandescent light bulb. During exposure, heat is dissipated by radiation.

The causes of tube failure are :

1- A single excessive exposure causes pitting or cracking of the anode.

2- Long exposure time causes excessive heating of the anode, resulting in damage to the bearings in the rotor assembly. Bearing damage causes warping and rotational friction of the anode.

3- Vaporization of the filament causes tungsten to coat the glass or metal enclosure; this eventually causes arcing.

1- A single excessive exposure causes pitting or cracking of the anode.

Enormous heat is generated in the anode of the x-ray tube during x-ray exposure. This heat must be dissipated for the x-ray tube to continue to function. This heat can be dissipated in one of three ways: **Radiation** is the transfer of heat by the emission of infrared radiation. Heat lamps emit not only visible light but also infrared radiation.

Conduction is the transfer of energy from one area of an object to another. The handle of a heated iron skillet becomes hot because of conduction.

Convection is the transfer of heat by the movement of a heated substance from one place to another. Many homes and offices are heated by the convection of hot air. Unfortunately, some heat is conducted through the neck of the anode to the rotor and glass enclosure. The heated glass enclosure raises the temperature of the oil bath; this convects the heat to the tube housing and then to room air. When the temperature of the anode is excessive during a single exposure, localized surface melting and pitting of the anode can occur. These surface irregularities result in variable and reduced radiation output. If surface melting is sufficiently severe, the tungsten can be vaporized and can plate the inside of the glass enclosure. This can cause filtering of the x-ray beam and interference with electron flow from the cathode to the anode.

2- Long exposure time causes excessive heating of the anode

Bearing damage: Excessive heating of the bearings results in increased rotational friction and an imbalance of the rotor anode assembly.

If thermal stress on the x-ray tube anode is maintained for prolonged periods, such as during fluoroscopy, the thermal capacity of the total anode system and of the x-ray tube housing is the limitation to operation. During fluoroscopy, the x-ray tube current is usually less than 5 mA, rather than hundreds of mA as in radiography. Under such fluoroscopic conditions, the rate of heat dissipation from the rotating target attains equilibrium with the rate of heat input, and this rate rarely is sufficient to cause surface defects in the target. However, the x-ray tube can fail because of the continuous heat delivered to the rotor assembly, the oil bath, and the x-ray tube housing. Bearings can fail, the glass enclosure can crack, and the tube housing can fail.

3- Vaporization of the filament

Vaporization of the filament, because of the high temperature of the filament, tungsten atoms are vaporized slowly and plate the inside of the glass or metal enclosure even with normal use. This tungsten, along with that vaporized from the anode, can disturb the electric balance of the x-ray tube, causing abrupt, intermittent changes in tube current, which often lead to arcing and tube failure.

The most frequent cause of abrupt tube failure is electron arcing from the filament to the enclosure because of vaporized tungsten. With excessive heating of the filament caused by high mA operation for prolonged periods, more tungsten is vaporized. The filament wire becomes thinner and eventually breaks, producing an open filament. This same type of failure occurs when an incandescent light bulb burns out.

Most x-ray imaging systems have a microprocessor control that does not allow an unsafe exposure.

Question: A 7-MHU helical CT x-ray tube is guaranteed for 50,000 scans, each scan limited to 5 s. What is the x-ray tube life in hours?

Answer: $Guaranteed\ life\ tube = 50000\ scans \times \frac{5\ sec}{scan} = 250000\ sec = 69\ hr$

X-RAY remedy and repair

Tube Reprocessing: Tube reprocessing involves replacing the oil inside the tube housing and removing any air, gases, particles that could cause arcing to re-establish vacuum inside the tube and increasing the strength of the insulation. This process could extend life of the tube by 20-50% more.

Tube Reloading: The replacement of a new tube insert into an old housing.

Preventing x-ray tube failure.

Use the standby setting.

Avoid high emission current.

Regularly inspect the casing.

Manage heat

References

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- Hendee W., and Ritenour E.,. (2002). *Medical Imaging Physics*. Willy-Liss,Inc