Fundamentals of Radio-physics

First Semester

Week7: Anode Cooling Chart

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➢ Anode Cooling Chart

-The anode has a limited capacity for storing heat. It is possible through prolonged use or multiple exposures to exceed the heat storage capacity of the anode.

Through diagrams it is possible:

-Determines the maximum heat capacity of the anode.

-Determines the length of time required for complete cooling following any level of heat input

-Different from the radiographic rating chart, the anode cooling chart **does not depend on** the **filament size or the speed of rotation.**

-The tube represented in Figure 1has a maximum anode heat capacity of 350,000 HU. The chart shows that if the maximum heat load were attained, it would take 15 minutes for the anode to cool completely.

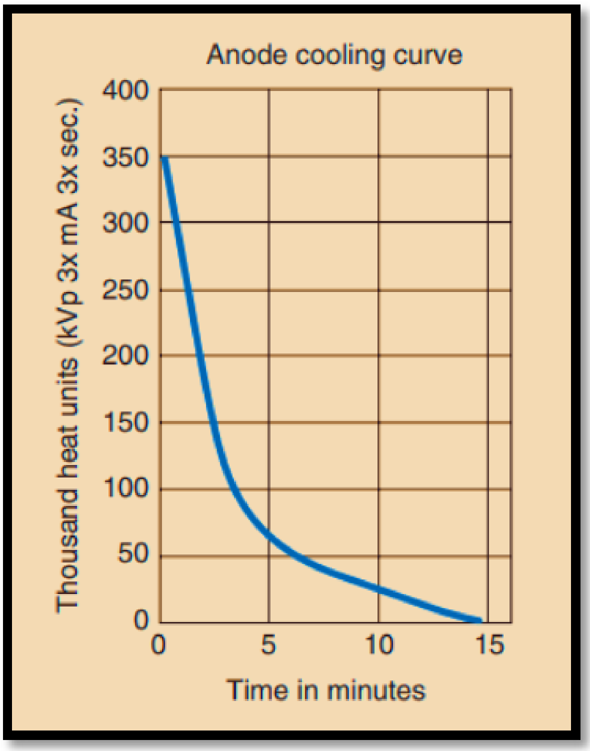

Figure1: Anode cooling chart shows time required for heated anode to cool.

-The rate of cooling is rapid at first and slows as the anode cools

During x-ray production, most of the kinetic energy of the electrons is converted to heat.

This heat can damage the x-ray tube and the anode target.

The amount of heat produced from any given exposure is expressed by the heat unit (HU).

Heat Units (HU) = (Tube voltage) (Tube current) (Time)
= (kVp) (mA) (sec) . Constant

Generator type	Constant
Single Phase 1φ	1
Three Phase 3φ	1.41
High Frequency	1.45

Example: Radiographic examination of the lateral lumbar spine with a single- phase imaging system requires 98 kVp, 120 mAs. How many heat units are generated by this exposure?

Heat Units (HU) = (Tube voltage) (Tube current) (Time)

$$HU= 98\ kVp \times 120 mAs \times 1= 11760\ J$$

Example: How much heat energy (in joules) is produced during a high-frequency mammographic exposure of 25 kVp, 200 mAs?

Heat Units (HU) = (Tube voltage) (Tube current) (Time)

$$HU = 25\ kVp \times 200\ mAs \times 1.45= 7250\ J$$

Example: A examination is performed with a high frequency imaging system at 120 kVp and 500 mA 0.7 s. Calculate the length of time necessary for the anode to cool to 50,000 HU after 5 exposures?

For one exposure

Heat Units (HU) = (Tube voltage) (Tube current) (Time)

$$HU = 120\ kVp \times 500mA \times 0.7s \times 1.45$$
$$= 60{,}900\ J$$

For 5 exposure

$$HU = 5 \times 60{,}900$$
$$= 304{,}500\ J$$

From the chart (Figure1), I went to just 50,000 HU which is about 6.25

➢ Heat production

- **Heat is produced in the focal spot area by the bombarding electrons from the cathod**e. Since only a small fraction of the electronic energy is converted in xradiation, it can be ignored in heat calculations. We will assume all of the electron energy is converted into heat.

➢ Heat Capacity

The heat capacity of the focal spot track is generally the limiting factor for single exposures. In a series of radiographic exposures, CT scanning, or fluoroscopy, **the build-up of heat in the anode can become significant. Excessive anode temperature can crack or warp the anode disc.**

➢ Protective X-ray Tube Housing

Every x-ray tube must be contained within protective housing that **reduces** leakage radiation during use.

- Leakage radiation is that radiation emitted from the x-ray tube housing in all directions other than that of the useful beam
- Leakage radiation must be less than 100 mR/hr (1 mGya/hr) at a distance of 1 m from the protective housing, while the tube operates at maximum output

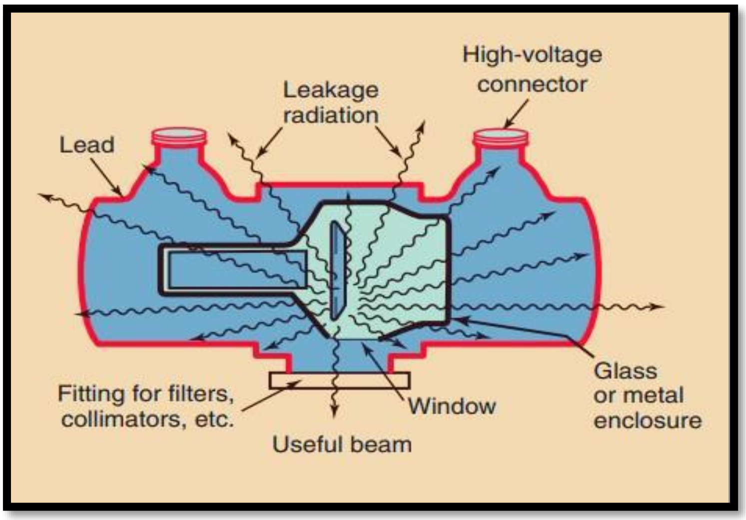

Figure 2: Protective housing reduces the intensity of leakage radiation to less than 1 mGya/hr at 1 m.

➢ Off-Focus Radiation

Some of the electrons bounce off the focal spot and then land on other areas of the target (see figure3), causing x-rays to be produced from outside of the focal spot

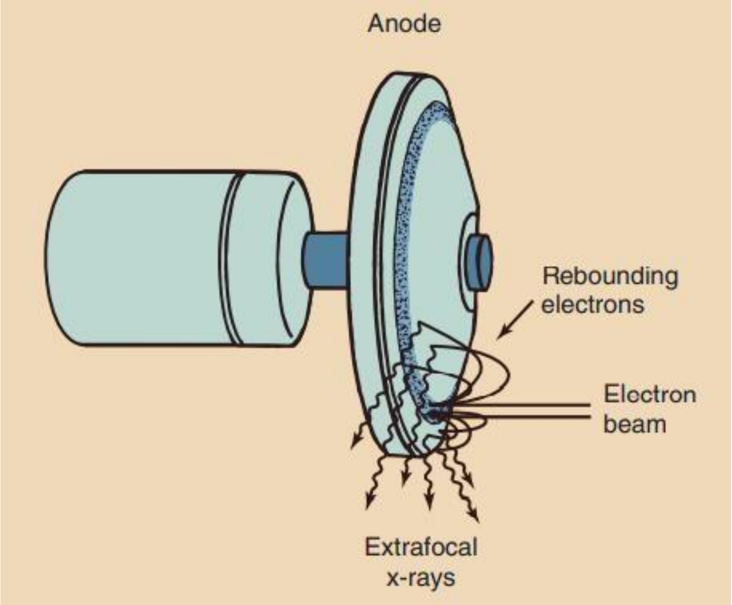

Figure3: Extrafocal x-rays result from interaction of electrons with the anode off of the focal spot.

Off-focus radiation is reduced by designing a fixed diaphragm in the tube housing near the window of the x-ray tube (Figure3). This is a geometric solution

Housing Cooling Chart

The cooling chart for the housing of the x-ray tube has a shape similar to that of the anode cooling chart and is used in precisely the same way.

- Based on the quantity of heat units, these charts provided radiographers with information regarding the amount of time that must elapse before initiating another exposure.