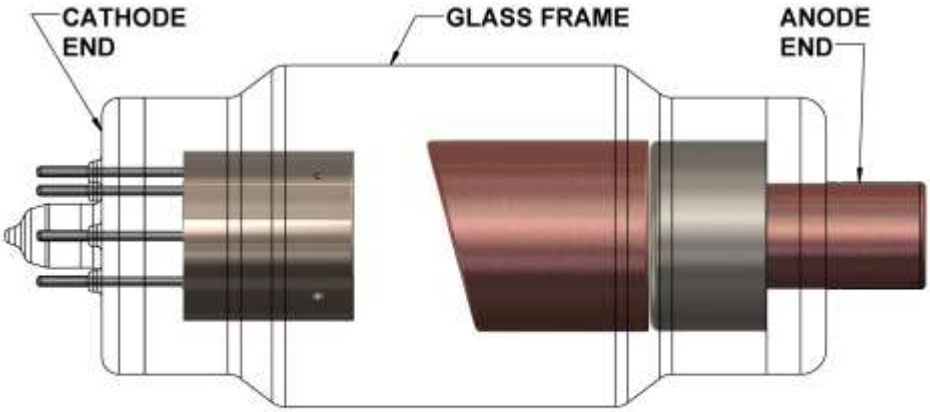
Anatomy of an x-ray tube

An x-ray tube is made from three basic parts; the cathode, the anode and the frame. There are many different types of x-ray tubes but, they all include these three basic parts in some fashion.



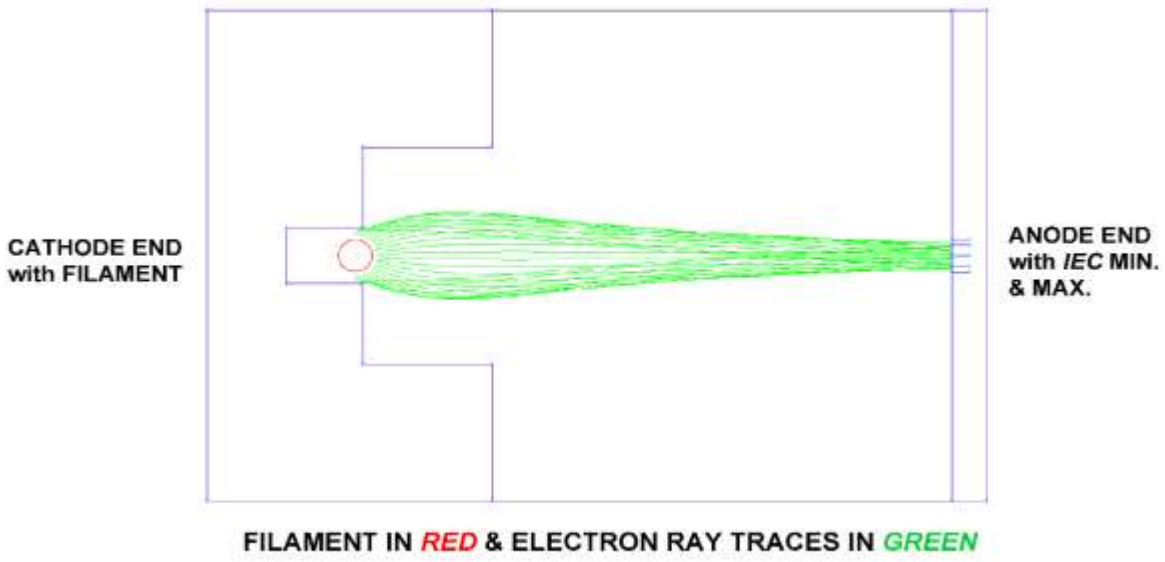
SXT (SUPERIOR X-RAY TUBE)
SXR 130-15-0.5 & 1.2DS

The cathode contains an emitter, focusing elements and pins for electrical connections. In operation, the cathode is always electrically more negative than its counterpart the anode (see SXT DUAL FOCUS CATHODE).

Cathode:
In the case of SXT (Superior X-Ray Tubes), our tubes are designed with a thermionic emitter (filament). They have a filament that is heated to the point it fluoresces and liberates electrons. These free electrons float about the filament area until the high voltage is applied.

SXT DUAL FOCUS CATHODE

Upon the application of high voltage, the electrons leave the cathode in a focused pattern influenced by the geometry of the focusing cup. The electrons are focused via the focus cup to hit a specific area on the target (see Electron Gun Ray Traces). The electrons hit the target material (typically tungsten). The cathode is designed using FEA software. The fast moving electrons liberate photons from the tungsten target. This transformation from electron to photon is a very inefficient process. The a vast amount of the electron beam energy is turned into heat and a small amount converts to photons.

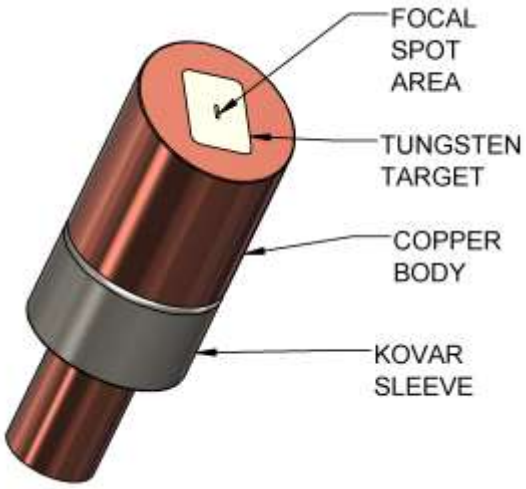


ELECTRON GUN "WIDTH" RAY TRACES

Anode:
The anode in a SXT has three distinct parts. The body of the anode. The body is made from copper. Copper is used because of its ability to conduct heat, and its melting point (see SUPERIOR 15° 45kHU ANODE).

The actual target of the anode is typically made from tungsten because of its very high melting point and high atomic number value. The high atomic number of tungsten when compared to other metals produces high bremsstrahlung production efficiency. Other materials are used based on the spectrum beam quality desired by a specific customer request.

There are at least two methods of getting the tungsten mated to the copper body. The first method is casting the copper around the tungsten target. This process is done using a sophisticated vacuum casting method. The other method used, is to braze the tungsten into the copper anode body. This method uses an atmospheric furnace. The anode body (copper) must remove as much heat as possible as quickly as possible to prevent damage to the surface of the target (melting). Whichever process is used, it needs to provide good intergranular penetration of the bonding material (copper or braze) and the tungsten, to maximize heat transfer.



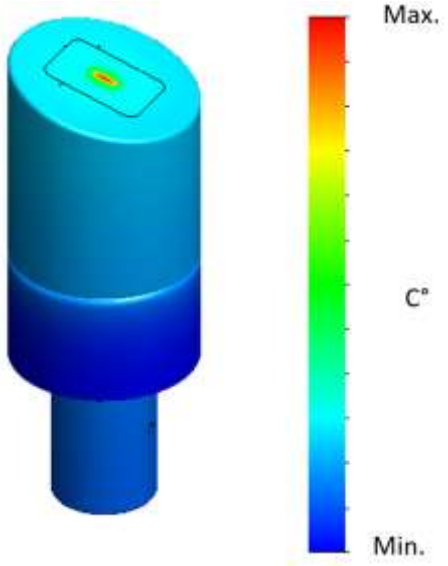
SXT 15° 45kHU ANODE

The third part of the anode assembly is a sleeve made from Kovar. Kovar is a nickel, cobalt, ferrous alloy. This alloy was developed to have the same thermal coefficient of expansion as borosilicate glass. Due to the similar thermal coefficient of expansion of kovar and glass, there is little stress induced in the glass frame when the metal parts expand.

The anode is a critical parts to the x-ray tube. Its design must support both short exposures (radiographic) and long exposures (fluoroscopic). To do this, the engineers at SXT, utilize thermal simulation FEA software to develop Maximum Single Exposure Rating" charts, as found in the SXT data sheets.

The use of this software and the interpretation of the output, allows SXT engineers to simulate many different exposure techniques and their effect on the anode body, anode shank and the focal spot on the face of the target. Many things go into the design of a SXT anode. The engineer must know processing, vacuum effects, materials and thermal heat transfer.

SXT makes many different tube types and sells them all over the world. Many tubes sold by SXT, are sold to many different customers. Each customer houses the tube differently. The environment also plays a significant role. All the things that make SXT customers different, insure that no tubes are operated the same way. Superior goes to great lengths to provide its customers with data (X-ray Tube Data Sheets) that provide guideline for safe use of the product.



SXT ANODE THERMAL SIMULATION

Glass:
Glass is used to maintain structural concentricity between the cathode and the anode while serving as the vacuum envelope. Additionally, glass is a good insulator providing electrical insulation between the anode and cathode. The glass used by SXT is designed to be low "Z" material thereby; reducing the glass attenuation of the ionized radiation output.

On inside of the glass envelope, there is a very good vacuum (1.0×10^{-7} or better). Because of this level of vacuum inside the tube, all the glass to metal and metal to metal seals need to be of the utmost quality to ensure no vacuum leak.