saes group SMI a SAES Group company Spectra-Mat, Inc.

TECHNICAL BULLETIN

Handling and Care of Cathodes

Porous tungsten with a formula of barium oxide dispersed throughout the matrix is the essential form of dispenser cathodes. Because BaO will absorb moisture and vapors, the cathodes are packed to minimize exposure and to keep out dust and other undesirable impurities. To insure optimum performance, cathodes should not be exposed to atmospheric conditions for more than 48 hours. Keep in a partial vacuum of 10^{-3} torr or better. Alternatively, store in inert gas (dry nitrogen or argon). The goal here is to keep the surface dry, away from the moisture found abundantly in the atmosphere.

Blisters may occasionally occur on the surface due to too rapid heating after inadvertent exposure to moisture during assembly and handling. These blisters may be avoided by a slower rate of heating increase.

All direct handling should be done with reasonable clean room processes. The addition of finger oils to a cathode will delay activation and may have an adverse affect on gun performance.

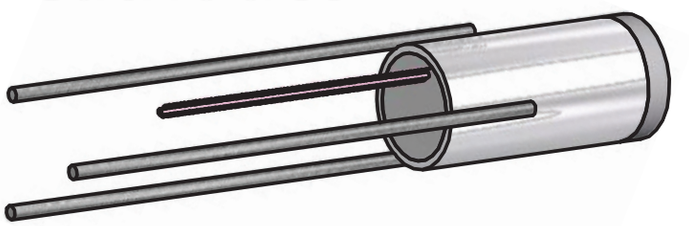
A dispenser cathode can be run at any temperature depending upon emission current and life requirements. High temperatures produce high emission current with shortened life. Lower temperatures extend life at lower emission current. In all cases, ultra-high vacuum levels extend cathode life.

Activation and Use

The following generic process will fully activate a dispenser cathode. The process is determined from work undertaken at Spectra-Mat and elsewhere. The instruction is offered as a guideline only. It is assumed that the cathode temperature vs. heater power has been calibrated prior, such that the temperatures quoted below can be set with reasonable accuracy.

Time, temperature and processing are subject to some changes for large tubes and tubes using ceramic-metal structures. Key to proper activation and long-life is pressure at the cathode – lower pressure during activation and use will always results in better performance. Activation is, surprisingly, impregnant type and/or coating independent.

Activation accomplishes two important tasks. It cleans the emitter surface of residual impurities and it oxygenates the emitter surface from residual oxygen found in the tungsten matrix. The latter step is the most important and is a diffusion process that takes time and temperature to fully accomplish.



a) Bake out the tube at the highest temperature consistent with tube constraints (brazes, material mismatches, etc.). During bake out it is desirable to heat the cathode to a temperature of not higher than 900°C. This will aid in removing water of hydration naturally present in the impregnant. Bake out should continue until the pressure in the tube decreases and is at or below 10-7 torr at the cathode, with the tube temperature elevated.

b) With the tube off bake-out and at room temperature, begin activation. Raise the cathode temperature slowly while monitoring the pressure. Cathode temperature should reach 1200°C[2]±25°C. Hold the temperature at 1200±25°C for ~ 2 hours. Pressure should rise very slightly inside the tube as temperature increases, but not too much.

c) At the end of the activation process (item b), the tube pressure should be in the 10-8 to 10-9 torr range and the cathode should be fully activated.

d) Cathode emission in a clean tube should now be readily available. The best test for emission is to direct measurement. Emission testing allows the end user to set the temperature a reasonable measure above the required output, either in the Fully Space Charge Limited regime or in the Temperature Limited regime. A typical temperature setpoint is 15% beyond the kneepoint[3].

Should pre-heating the cathode in a vacuum system be desired, certain precautions must be taken.

a) The cathode should not be heated to more than 900°C until the pressure in the vacuum system begins to drop. This will assure that the water of hydration found in the impregnant is fully removed.

b) Surrounding materials should be maintained clean and dry and be vacuum compatible.

In all circumstances, the key to cathode life remains high vacuum at the cathode.

1 Saturated DC emission as a function of temperature can be found in Spectra-Mat Technical Bulletin TB-117.
2 Temperatures are brightness temperatures.
3 The "kneepoint" is defined as the intersection point of the line approximately the emission vs temperature from both the FSCL and TL regimes.
For a discussion of kneepoints, FSCL and TL regimes, see Gilmour, A. S., (1986). Microwave Tubes. Dedham, MA: Artech House, chapter 5.