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TECHNICAL BULLETIN

Guidelines for Processing of Dispenser Cathodes

The processing of a dispenser cathode is quite straightforward, provided a few guidelines are followed. Cathode storage, cathode handling, contamination, humidity, pumping speed, vacuum level, pump location with respect to cathode, bake out temperature, cleanliness of tube components and preprocessing history will all influence the time to process a cathode but will not otherwise effect the process steps.

A critical consideration is to protect the cathode from either being poisoned or from poisoning itself.

To prevent cathode poisoning from the surrounding structure or from the gas products during bake-out, two steps are important:

Maintain adequate vacuum level at the cathode. The key here is "at the cathode" and not downstream at the gauge. There is often a very large pressure drop between the cathode and the gauge. The pressure at the cathode must be 1 x 10^{-7} torr or better at all times. As heater power is applied to the cathode for the first time, the pressure will increase as the temperature rises. If the pressure goes above 1 x 10-7 torr, back off on the power to the cathode until the pressure recovers. This out-gassing can take as long as a few minutes for a small point source emitter to several days for very large klystron cathodes.

Throughout the processing and bake-out process, keep the cathode temperature at or above the tube temperature. This will minimize any sublimation of evaporants from the tube onto the cathode.

To protect the cathode from poisoning itself, the following steps must be taken:

Moisture has the potential of permanently poisoning the cathode. If a cathode is ramped in temperature at such a rate that the moisture cannot escape, hydroxides and carbonates can form which not only reduce emission capabilities but also cause blistering and cracking of the tungsten emitter surface.

To prevent this, a cathode must be allowed to soak at two temperatures long enough to allow complete out-gassing of the water vapor. The first soak is at approximately 400°C. Holding at this temperature breaks down the hydrates formed with the barium-calcium -aluminates. Pressure will be a good indicator of the outgassing rate. Keep the pressure at l x 10-7 torr or better even at these low temperatures. This low temperature soak is especially important if the cathode has been exposed to air or humidity for an extended period.

The second soak is at approximately 900°C. At ~900°C O_2 O_5 W breaks down and combined with any adsorbed hydrogen allows the reduction of the tungstate to clean tungsten. Again, pressure is the best indicator. When the outgassing rate slows, pressure in the system will drop.

Activation after tube out-gassing and bake-out:

Activation is achieved by converting the barium oxide in the tungsten matrix into free barium on the surface of the cathode. The rate of activation is a function of tube cleanliness, cathode poisoning, time and temperature. All systems are different; there is no "standard" activation schedule. In general, the cathode is activated at or slightly above (+50 – 100 °C) the operating temperature. Cathode electron emission is the best indicator of activation. The cathode temperature should not exceed 1200°C[1]. Activation is also possible at lower temperatures (950-1000°C) but it will take longer.

Reactivation after air exposure:

A dispenser cathode can be used over and over if exposed to dry air while cool. The same considerations as mentioned above must be followed. The only difference is the out-gassing time may be reduced. Also, the once activated cathode will be very reactive when exposed to air. The cathode will be exceptionally sensitive to humidity and contamination. It is best to let the tube rest in dry nitrogen or another dry, inert gas.

Full Activation:

The dispenser cathode is fully activated by definition when it emits sufficient electrons to meet the needs of the end-user. Thus, the best test for activation is to pull emission from the cathode to the anode. When the cathode consistently meets or exceeds by about 15% the required electron flow, one can consider the activation complete.

1 1200°Cb is a good standard, but temperatures near 1200°Cb, either above or below, will not hurt the cathode and/or activation. That is, if one finds one has activated at (for example)1225°C for ten hours instead of 1200°C for eight hours, one can still use the cathode and expect excellent performance and life.