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P1.37: Emission Studies on Reservoir Cathodes

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Abstract: We report improved emission from our miniature reservoir cathodes due to changes in emission material composition and processes. Also, the diffuser plug porosity and composition were adjusted. The activity curves on diode testers now exhibit knee temperatures of 970º CB at 5 A/cm2. This is slightly above the "M" impregnated cathodes used as controls. Activation time was also reduced. The main improvement was introduction of sub-micron tungsten as activator in the reservoir and improved processes to protect emission material from water vapor. We present the data and describe the compositional and process changes that were made.

Keywords: Cathode; thermionic; reservoir cathode.

All dispenser cathodes are limited by their supply of barium and there are essentially just two ways to overcome it: lower the temperature to conserve existing barium or expand the supply of barium.

Reservoir cathodes follow the latter course. A barium containing compound plus activator is placed in a reservoir behind the diffuser plug, as shown in Figure 1. When heated, the barium compound is then reduced to barium in the reservoir, which travels to the diffuser plug surface. Because barium oxide is not reduced in the cathode pellet, there is no build-up of inert reaction by-products which would eventually block pores and cut off further barium evolution. This build-up is the fundamental problem with impregnated cathodes. It is the reason for the so-called "knee point migration" seen in all impregnated cathodes.

Reservoir cathodes, on the other hand, meter barium at a constant rate to the cathode surface for as long as barium remains in the reservoir. However, their long diffusion path from reservoir to emission surface introduces its own set of problems. Chief among these are slow activation and insufficient barium delivery to the surface.

This study addresses these problems. In it, we prepared various barium emission compounds in combination with various activators. The activator consisted of tungsten in various quantities and particle sizes. Direct measurements of barium desorption, both from open and closed reservoirs provided initial estimates on best materials and combinations.

We also addressed the serious problem of water contamination of barium-based emission compounds. We discovered a method for protecting these compounds from ambient air before and after the reservoir seal. This produced an immediate improvement in emission performance for cathodes.

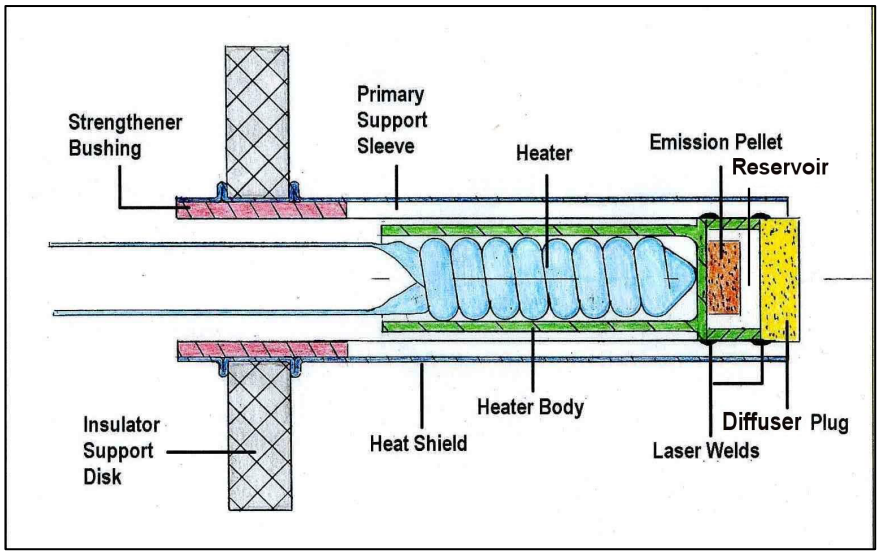

Figure 1. Diagram of Miniature Reservoir Cathode

In addition, diffuser plug composition and fabrication was addressed and processes generally were adjusted.

About 30 cathodes with the most promising attributes were tested in close-spaced diode testers.

The following conclusions were reached: Barium oxide was the only emission material tested that provided a sustained high delivery rate of barium to the cathode surface. But barium oxide is the most susceptible to water contamination of all the materials tested. Beneficial results occurred only when barium oxide processes occurred in vacuum or with an inert cover gas.

The best performing cathodes also used submicron tungsten powder, uniformly mixed with barium oxide, with a weight percentage of about 25%. The emission materials were not pelletized, contrary to the diagram in Figure 1. Mixed metal diffuser plugs made from osmium 35% - tungsten 65% produced poor emission. This was a puzzling result because this composition has produced results similar to "M" cathodes when used as an impregnated cathode. We found that densification of the matrix was occurring during the high temperature brazing operation to close the reservoir, and this accounted for the poor result.

In the study, the best cathodes employed an osmium thin film layer over a pure tungsten matrix comprised of 15-20 micron particles and sintered to 70% of theoretical density.

Figure 2 shows the cathode activity in a diode test at four anode voltages on a reservoir cathode utilizing the above mentioned improvements. 160 ma corresponds to 5 Amps/cm2. It shows an activity knee at about 970º CB. This is close to "M" cathode control cathodes in the same geometry and test environment. These cathodes achieved activity knees of 950 º CB at the same loading.

We saw on balance a shortening of activation time, although some cathodes were still slow to reach full emission. Most cathodes reached full emission in 100 hours, although one took 600 hours and one took over 1,000 hours to stabilize.

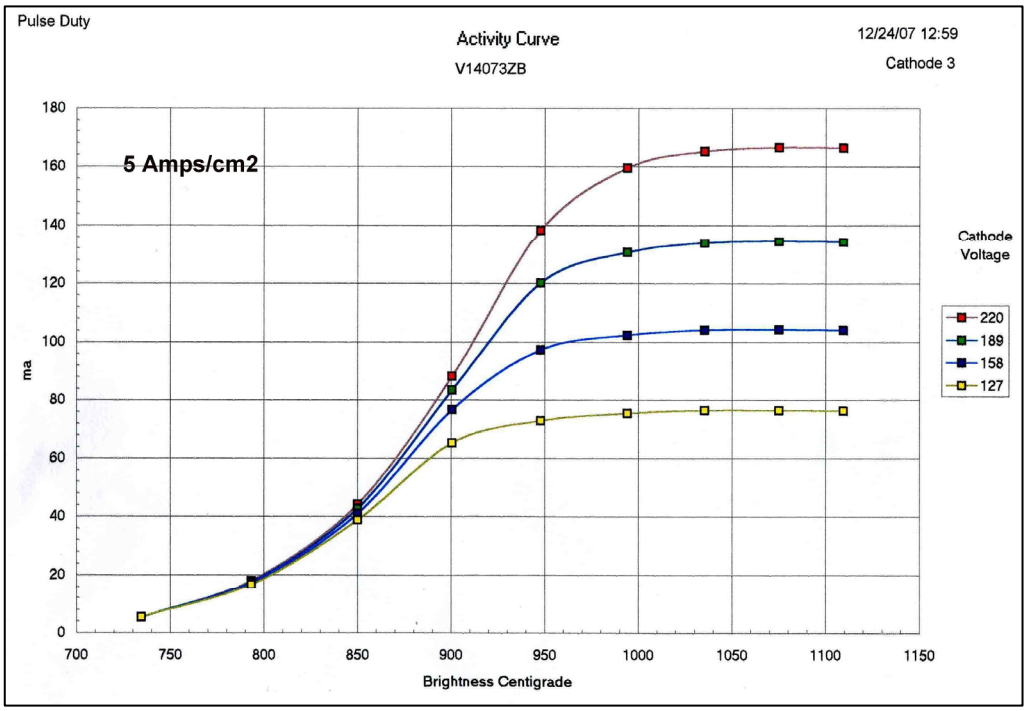

Figure 2. Activity Curve for Miniature Reservoir Cathode