

# ES-066 Barium Oxide Cathode Care and Operating Instructions

## INTRODUCTION

The Kimball Physics ES-066 is a low light Barium Oxide cathode. The ES-066 cathode structure consists of a barium oxide coated disc (diameter 0.062", 1.6 mm) that is directly heated by a tungsten hairpin and mounted on a standard AEI base or on a Kimball Physics CB-104 base.

## HANDLING

To protect the coating on the emission surface during storage and shipping, the cathode is sent in a non-activated (carbonate) form and needs a one-time activation by the user. The cathode should not be exposed to mechanical or thermal shock which can damage the emission surface. Once the cathode has been activated, care should be taken not to expose the cathode to air. Exposure to air allows the oxide to form hydrates which can cause flaking of the barium oxide. If the cathode needs to be exposed to air, the cathode should be restored to a vacuum environment as soon as possible, or be placed in a clean, dry environment (such as in a tightly sealed plastic box with desiccant).

## ACTIVATION

The activation process involves the conversion of carbonate to oxide, the release of barium from the metal-barium oxide interface, and the diffusion of the free barium. The ES-064 cathode needs a one-time activation using the following procedure:

1. Ensure initial vacuum of  $1 \times 10^{-7}$  torr or better. Vacuum poorer than the  $10^{-7}$  torr range may result in a poisoned cathode.

**CAUTION:** Monitor vacuum closely during all activation steps. Even though source current values are often given as operational benchmarks here, it is still assumed that the cathode is being driven by a voltage source.

2. Convert the carbonates into an oxide form:

- a. With no extraction voltage applied, gradually increase the cathode heating current from 0 to 3.15 A over a 20 minute (or longer) time span to allow outgassing while monitoring pressure. **Do not allow the vacuum to be poorer than  $1 \times 10^{-6}$  torr.** Increase the heating current from 0 to 1.5 A over 3 min. Then from 1.5 A to 2 A, increase by 0.1 A in 30 sec intervals. A small increase in the chamber pressure may be observed. After 2 A, proceed even more slowly as significant pressure increases may be observed, especially around 2.7 A just before the cathode begins to glow. At 3.15 A, the cathode brightness temperature will be about 1175 K.
- b. Remain at 3.15 A for 5 minutes, allowing for the formation of the BaO. The pressure should decrease again when the conversion is complete.

3. Create Barium:

- a. Create free Barium by slowly raising the cathode heating current to 3.3 A (brightness 1275 K). There may be a short duration of increased pressure.
- b. Maintain this temperature for a half hour.

4. Final activation:

**CAUTION:** Small changes in heating current have a greater effect on emission current at higher temperatures.

- a. Final activation of the cathode is obtained by gradually applying a DC extraction voltage for 1 minute to draw a cathode emission current that is approximately 10% more than the normal operating emission current. Do not let the pressure increase above  $1 \times 10^{-6}$  torr.
- b. Then slowly reduce the cathode heating current to a value between 3.0 A and 3.1 A (brightness 1075 K to 1150 K). This is the normal operating range for this cathode.
- c. Follow the operating procedure for turning off the cathode.

## OPERATING PROCEDURE

The operating procedure of the ES-066 cathode requires careful attention to the cathode heating current, cathode emission current, and chamber pressure, but should be driven by a voltage source rather than a current source. A current source will cause an unstable increase in cathode temperature, resistance and voltage which results in premature heater wire burnout. When driven by a voltage source, heater current decreases over time as the cathode temperature and resistance rise, resulting in stable power conditions.

1. Turning the cathode on:

- a. The recommended vacuum for operation of the BaO cathode is  $5 \times 10^{-7}$  torr or better.
- b. Establish a DC extraction voltage to allow monitoring of cathode emission current as the cathode heating current is increased.
- c. Now, gradually increase the cathode heating current to a value of approximately 3.0 A, proceeding slowly enough to keep the pressure below  $1 \times 10^{-6}$  torr. If little or no cathode emission current is present, further increase the cathode heating current in increments of 0.01 A until a sudden rise in emission current is observed. This should occur below 3.2 A.
- d. Once substantial emission current is observed, reduce the cathode heating current to between 3.0 A and 3.1 A as needed to provide the desired emission current. The cathode may drift a bit for the first half hour.
- e. Adjusting the applied DC extraction voltage or a suppression voltage will vary the cathode emission current.
- f. The recommended normal operating range for the heating current is 3.0 A to 3.1 A (brightness 1075 K to 1150 K). At lower temperatures, oxides may form, poisoning the cathode; at higher temperatures, cathode lifetime may be reduced due to loss of material.

2. Turning the cathode off:

- a. Gradually decrease the heating current to 0 A.
- b. After turning off the cathode and prior to removing the cathode from vacuum, allow the cathode to cool down to room temperature. Cool down time will vary depending upon the gun's structure and its temperature.
- c. It is recommended that the BaO cathode be stored in vacuum.