

**Barium Oxide Disc Cathode ES-015**  
*User Information*

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ES-015 Barium Oxide (BaO) Coated Disc Cathode mounted on AEI ceramic base.

**Introduction**

The Kimball Physics ES-015 is a low light Barium Oxide cathode. The ES-015 cathode structure consists of a barium oxide coated disc (diameter 0.033", 0.84 mm) that is directly heated by a tungsten hairpin and mounted on a standard AEI base or on a Kimball Physics compact ceramic base.

**Handling**

***Cathodes are fragile and caution must be used in handling. Do not touch the cathode structure itself, only the cathode base.***

The Barium Oxide Disc Cathode is shipped vacuum clean. When handling the cathode, the use of clean-room gloves is recommended to keep surfaces free of fingerprints or other contaminants.

To remove the cathode assembly from the purple shipping container:

- a) Place the purple base on a level surface.
- b) Holding onto the lower part (purple) of the shipping container, unscrew the

- c) upper cover (plexiglass) and remove it vertically to avoid hitting the cathode.
- c) Loosen the Philips screws to release clamp on the cathode.
- d) Carefully lift off the cathode assembly.



Example of Cathode Transport Container.



Example of cathode with AEI base secured in transport container base.

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-015 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 1.15 A over a 15 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.* After reaching 0.8 A, proceed slowly as significant pressure increases may be observed, especially just before the cathode begins to glow. At 1.15 A, the cathode brightness temperature will be about 1175 K.

b) Remain at 1.15 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 1.24 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 1.0 A and 1.13 A (brightness 1050 K to 1100 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-015 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 between 1.0 A and 1.10 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 1.20 A.

d. Once substantial emission current is observed, reduce the cathode heating current to between 1.0 A and 1.13 A as needed to provide the desired emission current. The cathode may drift a bit for the first half hour.

**Barium Oxide (BaO) Cathode Comparison Table**

Parameter	ES-015	ES-064	ES-066
CATHODE MATERIAL	Barium Oxide (BaO)	Barium Oxide (BaO)	Barium Oxide (BaO)
DISC SIZE	0.033 in dia. x .004 in thick (0.84 mm dia. x 0.1 mm thick)	0.048 in dia. x .004 in thick (1.22 mm dia. x 0.1 mm thick)	0.062 in dia. x .004 in thick (1.57 mm dia. x 0.1 mm thick)
HEATER WIRE SIZE	0.003 in dia. (0.08 mm dia.)	0.004 in dia. (0.1 mm dia.)	0.005 in dia. (0.13 mm dia.)
LEG LENGTH	approx. 0.11 in (2.8 mm)	approx. 0.12 in (2.8 mm)	approx. 0.15 in (3.8 mm)
HEIGHT ABOVE CERAMIC BASE	on CB-104 base: 0.14 in (3.5 mm) on AEI base: 0.256 in (6.5 mm)	on CB-105 base: 0.25 in (6.4 mm) on AEI base: 0.256 in (6.5 mm)	on CB-105 base: 0.27 in (6.9 mm) on AEI base: 0.256 in (6.5 mm)
EMISSION AREA	$5.52 \times 10^{-3} \text{ cm}^2$	$11.7 \times 10^{-3} \text{ cm}^2$	$19.5 \times 10^{-3} \text{ cm}^2$
EMISSION CURRENT	500 $\mu\text{A}$ typical	1 mA typical	2 mA typical
HEATING CURRENT	1.0A to 1.1 A	2.1 A to 2.3 A	3.0 A to 3.3 A
POWER SUPPLY CAPABILITY	Voltage regulated power supply recommended, 2 V, 2 A	Voltage regulated power supply recommended, 2 V, 3 A	Voltage regulated power supply recommended, 2 V, 4 A
CATHODE LOADING	0.1A/cm <sup>2</sup> recommended, typical; High loadings result in reduced lifetime		
CATHODE BASES	AEI, CB-104	AEI, CB-105	AEI, CB-105
WORK FUNCTION	1.0 eV to 1.8 eV, depending on experimental method		
OPERATING TEMP	1150 K typical		
ENERGY SPREAD	Approx. 0.3 eV		
LIFETIME	Thousands of hours with medium current and proper handling		
VACUUM LEVEL	$10^{-7}$ torr or better, recommended		
STORAGE	Dry Environment (vacuum or desiccant)		

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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 1.0 A to 1.13 A (brightness 1050 K to 1100 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 zero (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.

## Service for Repair / Breakage

If a problem arises during initial installation, please contact Kimball Physics. Cathodes may be returned to Kimball Physics for evaluation and possible repair with a return authorization number. In case of breakage, handle the cathode assembly with tweezers, being careful to touch only the base of the cathode. If broken off prior to usage, place the cathode in a capsule or in tissue or secure with double-sided adhesive, and return to Kimball Physics along with the cathode base in the original shipping tube.

## References

For more information on Cathode Operations, you may download additional detailed technical bulletins (not listed below) from the website Resources Page.

Cathodes- Emitters (Overview)

Barium Oxide Cathode (ES-015, ES-064, ES-066) - Cathodes / Emitters- (Overview)

Barium Oxide Cathode (ES-015) - Cathodes / Emitters: User Information

Barium Oxide Cathode (ES-064) - Cathodes / Emitters: User Information

Barium Oxide Cathode (ES-066) - Cathodes / Emitters: User Information

### Notes:

1. Charts /graphs show typical performance, data is for guidance only
2. It is not necessarily possible to achieve all maximum specifications simultaneously.
3. Specifications Subject to Change Without Notice.
4. DE Altobelli, DT Taylor 02/09/2023

Document: Barium\_Oxide\_ES\_015\_User\_Info\_2023\_0209  
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