

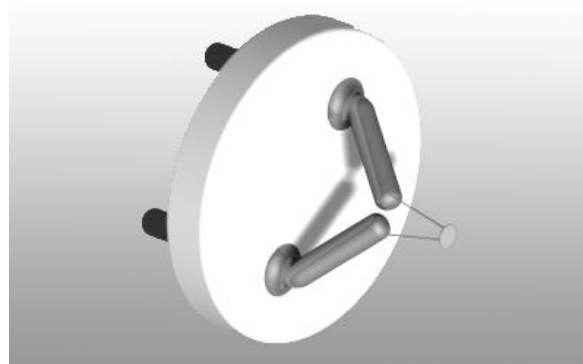
## ES-015, ES-064 and ES-066 BaO Coated Disc Cathodes

### FOR USE IN:

- Kimball Physics Electron Sources / Guns
- Custom Applications

### FEATURES / OPTIONS:

- Oxide Planar Cathode
- Low Light / Low Temperature
- Excellent Stability
- Low Energy Spread
- Accurately Pre-Aligned
- International Standard AEI Base
- Non-Standard Mounting Available



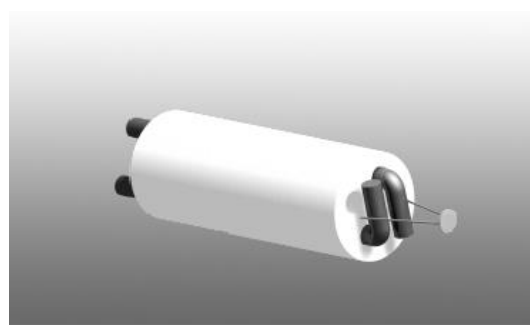
*Barium Oxide-Coated Disc Cathode mounted on a standard AEI ceramic base.*

The Kimball Physics Barium Oxide Cathode is a low-light, low-temperature thermionic emitter. The cathode structure of the ES-015, ES-064, and ES-066 consists of a barium oxide (BaO) coated disc substrate that is heated by conduction from a tungsten hairpin and mounted on an industry-standard ceramic AEI base or on a compact Kimball Physics ceramic base. Other bases are available on a custom basis. When ordering a spare cathode or firing unit for use in a Kimball Physics electron gun, simply specify the gun model and options (for example, EFG-7, standard energy, BaO) as this will determine the particular cathode configuration.

The BaO cathode has a lower cathode heating current range and a lower operating temperature than a standard, un-coated, refractory metal cathode, because BaO has a lower work function. With the lower temperatures, there is less light emitted which is an advantage in situations where light could interfere with viewing the target. The BaO cathode gives a smaller energy spread than a standard cathode, and has a longer lifetime due to the lower heating current. However, the BaO coating is susceptible to degradation from water vapor, so it is recommended that the barium oxide (BaO) cathode be operated in a vacuum of  $10^{-7}$  torr or

better. In addition, the cathode should be stored in vacuum or in a dry environment.

The performance of all coated cathodes will degrade as coating is 1) depleted through use, 2) lost due to mechanical shock, or 3) sputtered away by ion bombardment. The lifetime of a BaO-coated cathode is based on the evaporation rate or degradation of the coating materials and heater wire, which are dependent on the temperature at which the cathode is run and the quality of the vacuum. The work function of the cathode also affects its lifetime; contamination of the cathode surface can increase the work function, and thereby



*Barium Oxide Coated Disc Cathode mounted on CB-104 ceramic base,*

increasing the filament current needed to produce the same beam current. There are several factors to consider in choosing a cathode size.:

A larger disc has a larger emission area, with therefore more total current for a given current density. The current density of course is a monotonically increasing function of temperature. However, a larger disc loses more power to radiation, and thus more heating power is required.

A smaller disc tends to have a more uniform temperature distribution, which results in a more uniform emission.

Larger discs with larger legs tend to have a longer lifetime.

Kimball Physics has determined several combinations of cathode dimensions that have proved to work well in the Kimball Physics electron sources / guns. The model ES-015 utilizes a 0.033 inch (0.84 mm) diameter refractory metal disc coated with barium oxide, attached to a 0.003 inch (0.08 mm) diameter tungsten 3% rhenium heater wire. The higher current models, ES-064 and ES-066 have larger discs and thicker heater wires (see specifications table). Custom BaO cathodes are available with different disc sizes, and various heater designs.

The BaO disc cathode structure is available mounted on industry-standard ceramic AEI base, or on a Kimball Physics ceramic base (CB-104 or CB-105), as well as on custom or non-

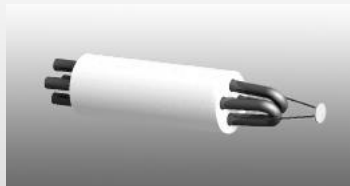
standard bases. Base options include two or four pins, pins made of molybdenum or Kovar, various pin lengths and positions, as well as different mounting heights of the cathode surface from the ceramic base. Some combinations of various options may not be possible due to design considerations.

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. If the BaO cathode is part of a Kimball Physics electron source / gun system, it will already have been activated during the gun testing in the laboratory. The activation process involves the conversion of carbonate to oxide, the release of barium to the metal-barium oxide interface, and the diffusion of the free barium.

Once the cathode has been activated care should be taken not to expose the cathode to air unnecessarily. Please refer to the BaO Care and Operating Instructions document referenced at the end of this document. Exposure to moisture in the 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). All cathodes are shipped vacuum clean.



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



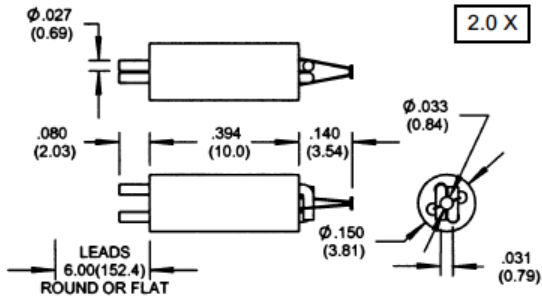
ES-064 Barium Oxide (BaO) Coated Disc Cathode mounted on CB-105 ceramic base.



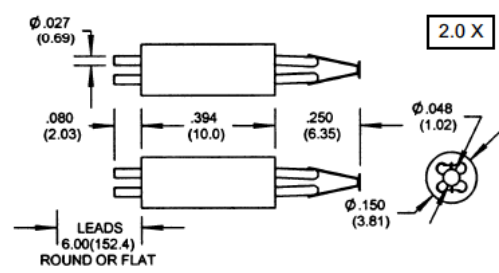
ES-066 Barium Oxide (BaO) Coated Disc Cathode mounted on CB-105 ceramic base.

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

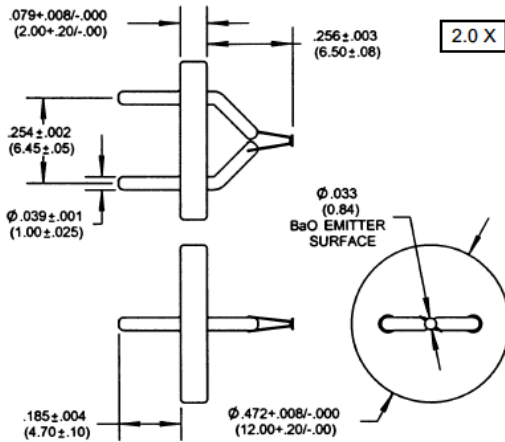
Parameter	ES-015	ES-064	ES-066
CATHODE MATERIAL	Barium Oxide (BaO)	Barium Oxide (BaO)	Barium Oxide (BaO)
DISC SIZE	0.033 in dia. x .004 in thick (0.84 mm dia. x 0.1 mm thick)	0.048 in dia. x .004 in thick (1.22 mm dia. x 0.1 mm thick)	0.062 in dia. x .004 in thick (1.57 mm dia. x 0.1 mm thick)
HEATER 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)		



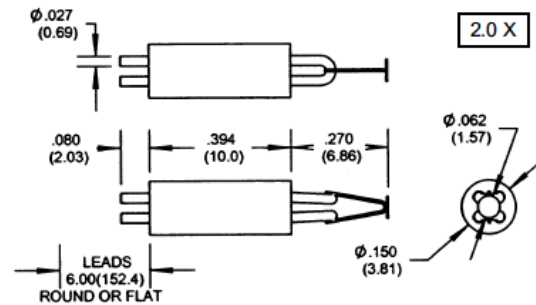
ES-015 Barium Oxide Disc Cathode mounted on a CB-104 ceramic base



ES-064 Barium Oxide Disc Cathode mounted on a high current CB-105 ceramic base



ES-015 Barium Oxide Disc Cathode mounted on an AEI ceramic base  
ES-064 and ES-066 also available on AEI bases



ES-066 Barium Oxide Disc Cathode mounted on a high current CB-105 ceramic base

ALL DIMENSIONS ARE IN INCHES  
(MILLIMETERS IN PARENTHESES)

## 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 2/09/2023

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