



## Cernox® RTDs

### Cernox® features

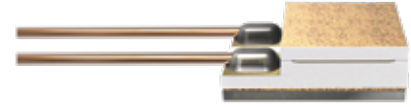
- Low magnetic field-induced errors
- Temperature range of 100 mK to 420 K (model dependent)
- High sensitivity at low temperatures and good sensitivity over a broad range
- Excellent resistance to ionizing radiation
- Bare die sensor with fast characteristic thermal response times: 1.5 ms at 4.2 K, 50 ms at 77 K
- Broad selection of models to meet your thermometry needs
- Excellent stability
- Variety of packaging options



**CAUTION:** These sensors are sensitive to electrostatic discharge (ESD). Use ESD precautionary procedures when handling, or making mechanical or electrical connections to these devices in order to avoid performance degradation or loss of functionality.

Cernox® thin film resistance temperature sensors offer significant advantages over comparable bulk or thick film resistance sensors. The smaller package size of these thin film sensors makes them useful in a broader range of experimental mounting schemes, and they are also available in a chip form. They are easily mounted in packages designed for excellent heat transfer, yielding a characteristic thermal response time much faster than possible with bulk devices requiring strain-free mounting. Additionally, they have been proven very stable over repeated thermal cycling and under extended exposure to ionizing radiation.

CX-SD



CX-BR



### Packaging options

AA, BC, BG, BO, BR, CD,  
CO, CU, ET, LR, MT, SD

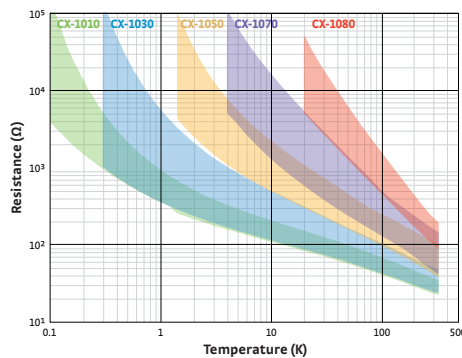
### CX-1010—the ideal replacement for germanium RTDs

The CX-1010 is the first Cernox® designed to operate down to 100 mK, making it an ideal replacement for Germanium RTDs. Unlike Germanium, all Cernox models have the added advantage of being able to be used to room temperature. In addition, Cernox is offered in the incredibly robust Lake Shore SD package, giving researchers more flexibility in sensor mounting.

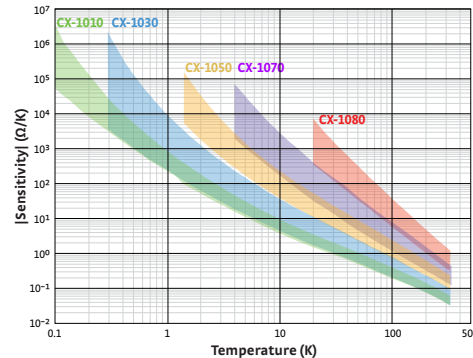
### The Lake Shore SD package — the most rugged, versatile package in the industry

The SD package, with direct sensor-to-sapphire base mounting, hermetic seal, and brazed Kovar leads, provides the industry's most rugged, versatile sensors with the best sample to chip connection. Designed so heat coming down the leads bypasses the chip, it can survive several thousand hours at 500 K (depending on model) and is compatible with most ultra high vacuum applications. It can be indium soldered to samples without shift in sensor calibration. If desired, the SD package is also available without Kovar leads.

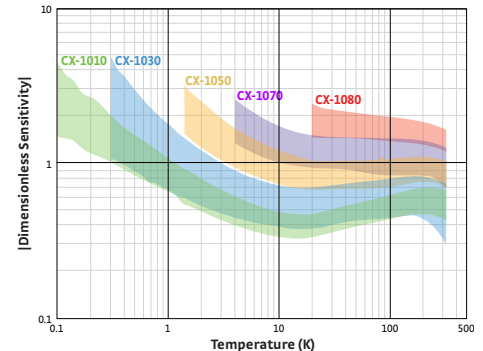
### Typical Cernox® resistance



### Typical Cernox® sensitivity



### Typical Cernox® dimensionless sensitivity





## Specifications

**Standard curve** Not applicable

**Recommended excitation**<sup>1</sup> 20  $\mu$ V (0.1 K to 0.5 K); 63  $\mu$ V (0.5 K to 1 K); 10 mV or less for  $T > 1.2$  K

**Dissipation at recommended excitation** Typical  $10^{-5}$  W at 300 K,  $10^{-7}$  W at 4.2 K,  $10^{-13}$  W at 0.3 K (model and temperature dependent)

**Thermal response time** BC, BR, BG: 1.5 ms at 4.2 K, 50 ms at 77 K, 135 ms at 273 K; SD: 15 ms at 4.2 K, 0.25 s at 77 K, 0.8 s at 273 K; AA: 0.4 s at 4.2 K, 2 s at 77 K, 1.0 s at 273 K

**Use in radiation** Recommended for use in radiation environments—see Appendix B

**Use in magnetic field** Recommended for use in magnetic fields at low temperatures. The magnetoresistance is typically negligibly small above 30 K and not significantly affected by orientation relative to the magnetic field—see Appendix B

**Reproducibility**<sup>2</sup>  $\pm 3$  mK at 4.2 K

**Soldering standard** J-STD-001 Class 2

<sup>1</sup> Recommended excitation for  $T < 1$  K based on Lake Shore calibration procedures using an AC resistance bridge—for more information refer to Appendix D and Appendix E

<sup>2</sup> Short-term reproducibility data is obtained by subjecting sensor to repeated thermal shocks from 305 K to 4.2 K

## Range of use

|         | Minimum limit       | Maximum limit |
|---------|---------------------|---------------|
| Cernox® | 0.10 K <sup>3</sup> | 420 K         |

<sup>3</sup> Model dependent

## Calibrated accuracy<sup>4</sup>

|       | Typical sensor accuracy <sup>5</sup> | Long-term stability <sup>6</sup> |
|-------|--------------------------------------|----------------------------------|
| 1.4 K | $\pm 5$ mK                           | $\pm 3$ mK                       |
| 4.2 K | $\pm 5$ mK                           | $\pm 3$ mK                       |
| 10 K  | $\pm 6$ mK                           | $\pm 6$ mK                       |
| 20 K  | $\pm 9$ mK                           | $\pm 12$ mK                      |
| 30 K  | $\pm 10$ mK                          | $\pm 18$ mK                      |
| 50 K  | $\pm 13$ mK                          | $\pm 30$ mK                      |
| 77 K  | $\pm 16$ mK                          | $\pm 46$ mK                      |
| 300 K | $\pm 60$ mK                          | $\pm 180$ mK                     |
| 400 K | $\pm 65$ mK                          | —                                |

<sup>4</sup> Bare chip sensors can only be calibrated after attaching gold wire leads—the user must remove the ball bonded leads if they are not desired (the bond pads are large enough for additional bonds)

<sup>5</sup> [(Calibration uncertainty)<sup>2</sup> + (reproducibility)<sup>2</sup>]<sup>0.5</sup> for more information see Appendices B, D, and E

<sup>6</sup> Long-term stability data is obtained by subjecting sensor to 200 thermal shocks from 305 K to 77 K

## Typical magnetic field-dependent temperature errors<sup>7</sup> $\Delta T/T$ (%) at B (magnetic induction)

|       | Cernox® 1050 |       |       |       |
|-------|--------------|-------|-------|-------|
|       | 2.5 T        | 8 T   | 14 T  | 19 T  |
| 2 K   | 1.3          | 3.1   | 3.9   | 5     |
| 4.2 K | 0.1          | -0.15 | -0.85 | -0.8  |
| 10 K  | 0.04         | -0.4  | -1.1  | -1.5  |
| 20 K  | 0.04         | 0.02  | -0.16 | -0.2  |
| 30 K  | 0.01         | 0.04  | 0.06  | 0.11  |
| 77 K  | 0.002        | 0.022 | 0.062 | 0.11  |
| 300 K | 0.003        | 0.004 | 0.004 | 0.006 |

<sup>7</sup> Excellent for use in magnetic fields, depending on temperature range (>2 K)

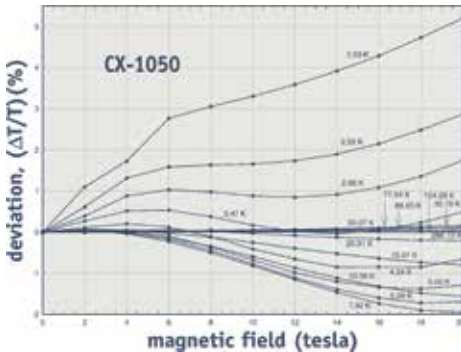
## Temperature response data table (typical)

|          | CX-1010            |             |               | CX-1030            |             |               | CX-1050            |             |               | CX-1070            |             |               | CX-1080            |             |               |
|----------|--------------------|-------------|---------------|--------------------|-------------|---------------|--------------------|-------------|---------------|--------------------|-------------|---------------|--------------------|-------------|---------------|
|          | R <sup>8</sup> (Ω) | dR/dT (Ω/K) | (T/R)·(dR/dT) | R <sup>8</sup> (Ω) | dR/dT (Ω/K) | (T/R)·(dR/dT) | R <sup>8</sup> (Ω) | dR/dT (Ω/K) | (T/R)·(dR/dT) | R <sup>8</sup> (Ω) | dR/dT (Ω/K) | (T/R)·(dR/dT) | R <sup>8</sup> (Ω) | dR/dT (Ω/K) | (T/R)·(dR/dT) |
| 4.2      | 277.32             | -32.209     | -0.49         | 574.20             | -97.344     | -0.71         | 3507.2             | -1120.8     | -1.34         | 5979.4             | -2225.3     | -1.56         | —                  | —           | —             |
| 10       | 187.11             | -8.063      | -0.43         | 331.67             | -19.042     | -0.57         | 1313.5             | -128.58     | -0.98         | 1927.2             | -214.11     | -1.11         | —                  | —           | —             |
| 20       | 138.79             | -3.057      | -0.44         | 225.19             | -6.258      | -0.56         | 692.81             | -30.871     | -0.89         | 938.93             | -46.553     | -0.99         | 6157.5             | -480.08     | -1.56         |
| 30       | 115.38             | -1.819      | -0.47         | 179.12             | -3.453      | -0.58         | 482.88             | -14.373     | -0.89         | 629.90             | -20.613     | -0.98         | 3319.7             | -165.61     | -1.50         |
| 77.35    | 70.837             | -0.510      | -0.56         | 101.16             | -0.820      | -0.63         | 205.67             | -2.412      | -0.91         | 248.66             | -3.150      | -0.98         | 836.52             | -15.398     | -1.42         |
| 300      | 30.392             | -0.065      | -0.65         | 41.420             | -0.088      | -0.64         | 59.467             | -0.173      | -0.87         | 66.441             | -0.201      | -0.91         | 129.39             | -0.545      | -1.26         |
| 400 (HT) | —                  | —           | —             | 34.779             | -0.050      | -0.57         | 46.782             | -0.093      | -0.79         | 51.815             | -0.106      | -0.81         | 91.463             | -0.261      | -1.14         |
| 420 (HT) | —                  | —           | —             | 33.839             | -0.045      | -0.55         | 45.030             | -0.089      | -0.77         | 49.819             | -0.094      | -0.80         | 86.550             | -0.231      | -1.12         |

<sup>7</sup> See Appendix G for expanded response table

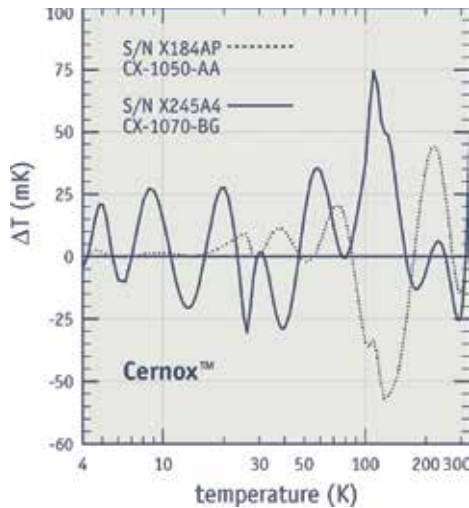
<sup>8</sup> Cernox sensors do not follow a standard response curve — the listed resistance ranges are typical, but can vary widely; consult Lake Shore to choose a specific range

**Magnetic field dependence data for sample CX RTDs**

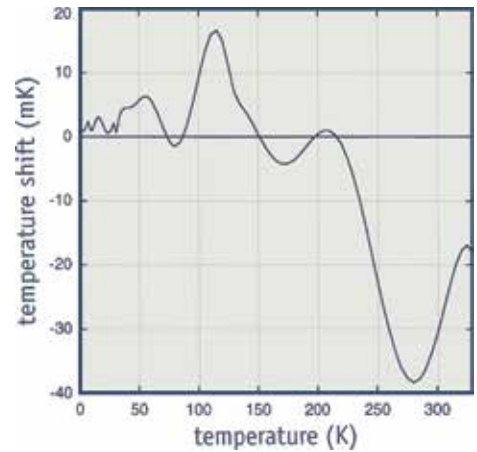


Typical temperature reading errors for operation of CX-1050 sensors in magnetic fields at temperatures from 2.03 K to 286 K. "Low temperature thermometry in high magnetic fields VII. Cernox® sensors to 32 T," B. L. Brandt, D. W. Liu and L. G. Rubin; Rev. Sci. Instrum., Vol. 70, No. 1, 1999, pp 104-110.

**Neutrons and gamma rays**

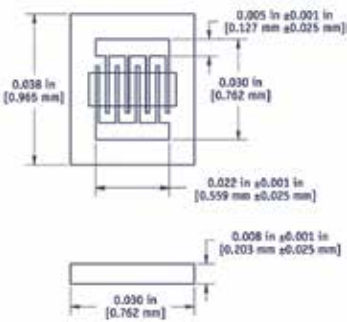


**Typical calibration shifts**

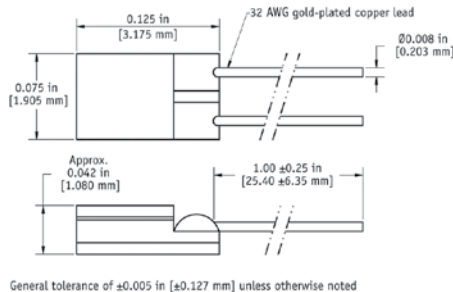


Typical calibration shift after 200 thermal shocks from 305 K to 77 K for a Model CX-1030 temperature sensor (ΔT = 1 mK at 4.2 K and 10 mK at 100 K).

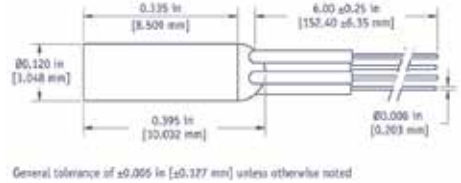
**CX-BR**



**CX-SD**



**CX-AA**

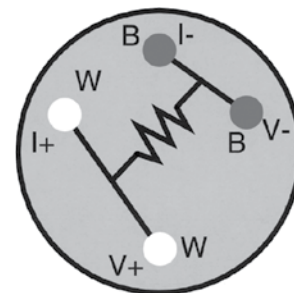


**Physical specifications**

|                               | Mass     | Lead type  | Internal atmosphere                     | Sensor materials used   |
|-------------------------------|----------|--|---|---|
| Bare chip (BC), (BG), (BR)    | ≤ 3.0 mg | BR: none<br>BG: two 2 mil (44 AWG) bare gold<br>25 mm long wires<br>BC: two 2.5 mil (42 AWG) bare copper<br>25 mm long wires | NA                                      | Ceramic oxynitride, gold pads and sapphire substrate with Au Pt Mo back (chip in all models)  |
| Hermetic ceramic package (SD) | ≈ 40 mg  | 2 gold-plated copper   | Vacuum                                  | Chip mounted on sapphire base with alumina body and lid, Mo/Mn with nickel and gold plating on base and lid, gold-tin solder as hermetic lid seal, 63/37 SnPb solder used to attach leads |
| Copper canister package (AA)  | ≈ 390 mg | 4 phosphor bronze with HML heavy build insulation attached with epoxy strain relief at sensor                                | Helium 4 ( <sup>4</sup> He) is standard | Chip mounted in a gold plated cylindrical copper can  |

**AA package**

Wires with the same color code are connected to the same side of the sensor (looking at epoxy seal with leads toward user)



## Ordering information

**Uncalibrated sensor**—Specify the model number in the left column only, for example CX-1050-CD.

**Calibrated sensor**—Add the calibration range suffix code to the end of the model number, for example CX-1050-CD-1.4L.



| Cernox® RTD                              | Calibration range suffix codes   |      |      |      |      |      |      |    |    |     |     |
|--|--|------|------|------|------|------|------|----|----|-----|-----|
|  | Numeric figure is the low end of the calibration<br>Letters represent the high end: L=325 K, M=420 K |      |      |      |      |      |      |    |    |     |     |
|  | Uncal  | 0.1L | 0.1M | 0.3L | 0.3M | 1.4L | 1.4M | 4L | 4M | 20L | 20M |
| CX-1010-AA, -BC, -BO, -CD, -ET, -LR, -MT | ■  | ■    |      |      |      | ■    |      |    |    |     |     |
| CX-1010-BG-HT, -BR-HT                    | ■  |      |      |      |      |      |      |    |    |     |     |
| CX-1010-CO-HT, -CU-HT, -SD-HT            | ■  | ■    | ■    |      |      | ■    | ■    |    |    |     |     |
| CX-1030-AA, -BC, -BO, -CD, -ET, -LR, -MT | ■  |      |      | ■    |      | ■    |      |    |    |     |     |
| CX-1030-BG-HT, -BR-HT                    | ■  |      |      |      |      |      |      |    |    |     |     |
| CX-1030-CO-HT, -CU-HT, -SD-HT            | ■  |      |      | ■    | ■    | ■    | ■    |    |    |     |     |
| CX-1050-AA, -BC, -BO, -CD, -ET, -LR, -MT | ■  |      |      |      |      | ■    |      |    |    |     |     |
| CX-1050-BG-HT, -BR-HT                    | ■  |      |      |      |      |      |      |    |    |     |     |
| CX-1050-CO-HT, -CU-HT, -SD-HT            | ■  |      |      |      |      | ■    | ■    |    |    |     |     |
| CX-1070-AA, -BC, -BO, -CD, -ET, -LR, -MT | ■  |      |      |      |      |      |      | ■  |    |     |     |
| CX-1070-BG-HT, -BR-HT                    | ■  |      |      |      |      |      |      |    |    |     |     |
| CX-1070-CO-HT, -CU-HT, -SD-HT            | ■  |      |      |      |      |      |      | ■  | ■  |     |     |
| CX-1080-AA, -BC, -BO, -CD, -ET, -LR, -MT | ■  |      |      |      |      |      |      |    |    | ■   |     |
| CX-1080-BG-HT, -BR-HT                    | ■  |      |      |      |      |      |      |    |    |     |     |
| CX-1080-CO-HT, -CU-HT, -SD-HT            | ■  |      |      |      |      |      |      |    |    | ■   | ■   |

**ADD -P** Add spot-welded platinum leads to the SD package for Cernox® sensors only

### Accessories available for sensors

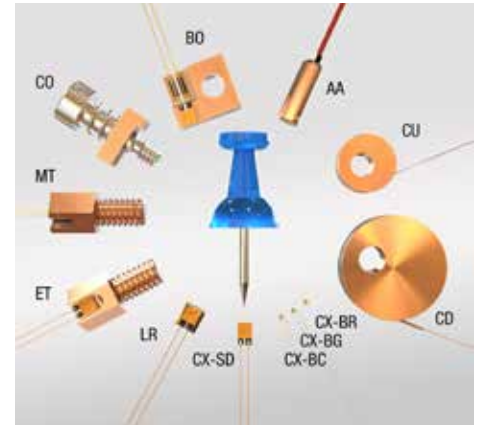
- SN-CO-C1 SD package sensor clamp, qty 1
- SN-CO-C10 SD package sensor clamp, qty 10
- 8000-CD Calibration report on CD-ROM
- 8000-USB Calibration report on USB
- COC-SEN Certificate of conformance

### Accessories suggested for installation—

- see Accessories section for full descriptions
- Stycast® epoxy
  - Apiezon® grease
  - 90% Pb, 10% Sn solder
  - Indium solder
  - VGE-7031 varnish
  - Phosphor bronze wire
  - Manganin wire
  - CryoCable™

## Packaging options

For more information on sensor packages and mounting adapters, see page 20.



**CO adapter** — spring loaded clamp for easy sensor interchangeability



See the appendices for a detailed description of:

- Installation
- Uncalibrated sensors
- SoftCal™
- Calibrated sensors
- CalCurve™
- Sensor packages

To add length to sensor leads, see page 25.