

Manufacturer's Custom & Flight Qualifications



EXPERIENCE:

Since 1968, **Lake Shore Sensors** have provided the most versatile, accurate, and dependable performance in the industry. For over 20 years, the major aerospace companies around the world have depended on **Lake Shore Cryotronics, Inc.** to supply flight qualified temperature sensors for their major aerospace programs. We routinely provide chip lot traceability, die shear test, ball bond pluck tests, and wire pull tests. We can fully comply with pre-cap inspection requirements and final source inspections.

CONTROLS:

For each production lot, Lake Shore generates a shop traveller outlining all manufacturing steps and testing required to control a specific work order. The traveller is generated by a Sensor Division Manufacturing Engineer (or equivalent function) and contains all relevant information to the work order including:

- sensor model number
- production lot number
- Lake Shore work order number
- customer specification number
- purchase order number
- step number, detailed instructions, date operation started and completed, authorized inspector, and stamp if required.

The Sensor Division Production Manager ensures that the work order is processed in a timely fashion.

Critical processes are controlled by a combination of destructive testing of sample parts and detailed data analysis. All manufacturing steps are completed at the Lake Shore facility by Lake Shore personnel. Subcontracted Military Standard testing is performed by approved and authorized test laboratories. A list of typical MIL-STD-750 tests routinely requested by customers follows:

- Precap inspection (2072)
- Bond pull test (2037)
- Die shear test (2017)
- PIND test (method 2052)
- Fine and gross hermetic seal test (method 1071)
- Constant acceleration test (method 2006)
- High temperature reverse bias (method 1038) (diode only)
- High temperature life test (method 1032)
- Steady-state life test (method 1027)
- Steady-state life test (method 1038) (diode only)
- Burn-in test (method 1038) (diode only)
- Radiography test (method 2076)
- Shock test (method 2016)
- Vibration, variable frequency (method 2056)
- Solderability (method 2026)
- Steady-State total dose irradiation (MIL-STD-883, method 1019)

Upon customer request, material certification and certificate of conformance are also provided.

CALIBRATION (Electrical Testing):

Lake Shore possess a fully certified cryogenic temperature calibration facility. The temperature calibration facility and procedures for diode and resistance sensor calibrations are maintained traceable in accordance with MIL-STD-45662A.

BUILDING:

Lake Shore facilities are housed in a new, 54,000 square foot building designed for its manufacturing and business activities. It incorporates offices, training and conference facilities, machine shops, clean rooms, laboratories, and flexible manufacturing floor space.

MILITARY SPECIFICATIONS AVAILABLE IN SENSOR PRODUCTION

<u>#</u>	<u>MIL-STD</u>	<u>DESCRIPTION</u>
1.	S-19500	General spec. for semiconductor devices
2.	750C	Test method for semiconductor devices
3.	883B	Test methods and procedures for microelectronics
4.	45662A	Calibration system requirements
5.	202F	Test methods for electronic and electrical component parts
6.	414	Sampling method for inspection by variables
7.	105	Sampling method for inspection by attributes
8.	1535A	Supplier QA program requirement
9.	810D	Environmental test methods and engineering guidelines
10.	781C	Reliability design qualification and product acceptability tests
11.	961A	Preparation of military spec. and associated documents
12.	1188A	Commercial packaging of supplies and equipment
13.	1189	Standard symbology for marking
14.	129H	Marking of shipment and storage
15.	130F	Identification of military property
16.	E-55585E	Packaging of electronic equipment and parts
17.	252B	Classification of visual and mechanical defects for equipment, electronic wired, and other devices
18.	I-15126F	Insulation tape, pressure sensitive adhesives, and pressure sensitive thermosetting adhesives
19.	I-45208	Inspection system requirement
20.	M-38510D	General specification for microelectronics
21.	P-116H	Preservation method
22.	975H	NASA standard electrical, electronic, and electro-mechanical parts list

NOTE: Items 1 – 4 are the most commonly used in sensor production

CERNOX™ Resistance Temperature Sensor

Technical Data

Lake Shore Cernox™ resistance temperature sensors are ideally suited to the detection and measurement of cryogenic temperatures in space applications. These sensors consist of a refractory metal oxy-nitride thin films deposited on sapphire substrates by sputter deposition. The sensors vary monotonically in resistance over their entire useful temperature range. A variety of models are available with resistance and temperature sensitivity matched to specific temperature ranges. A typical resistance response curve for each model is shown in Figure 1, while temperature sensitivity data is shown in Figure 2. The sensors do not follow a standard curve, so individual calibrations are necessary for accurate temperature measurement over the range of interest. Calibrations are performed in the Lake Shore temperature sensor calibration facility. The Lake Shore calibration facility and procedures for diode and resistance sensor calibrations above 0.65 K are maintained traceable in accordance with MIL-STD-45662A to the International Temperature Scale of 1990.

Specification (Note: some parameters are model dependent):

Stress above the absolute maximum rating may cause permanent damage to the device. Extended operation at the maximum levels may degrade performance and affect reliability.

Absolute maximum rating:

Maximum Power (W):	Minimum of 10^{-4} W, 10 mA, or 1 V, whichever is least
Maximum Soldering temperature:	200 °C
Maximum Storage temperature range:	0.3 K to 325 K

Model recommendations:

Temperature Range:	
0.3 K to 420 K	CX-1020
0.3 K to 420 K	CX-1030
1.4 K to 420 K	CX-1050
4.0 K to 420 K	CX-1070
20 K to 420 K	CX-1080

Recommended operating conditions:

Operating temperature range:	0.3 K to 425 K
Excitation voltage (V_{exc}):	100 μ V for $0.3 < T < 1.4$ K, 10 mV for $T > 1.4$ K,
Accuracy (calibrated):	± 5 mK at $T < 10$ K, ± 20 mK at 20 K ± 35 mK at 50 K, ± 50 mK at 100 K ± 140 mK at 300 K
Dissipation at rated excitation:	Typical 10^{-8} W at 4.2 K, 10^{-7} W at 77 K, 10^{-6} W at 300 K
Units range:	10 to 100,000 ohms
Recommended recalibration schedule:	Annual
Thermal response time in SD package:	Typical < 15 ms at 4.2 K; 250 ms at 77 K; 800 ms at 305 K



Stability:

Short term:	± 3 mK at 4.2 K; ± 15 mK at 77 K, ± 40 mK at 300 K);
Long term (per year):	± 10 mK at 4.2 K, ± 25 mK at 77 K, $\pm 0.05\%$ of temperature for $100 \text{ K} < T < 325 \text{ K}$

Technical Data (continued)

Physical Specification: (SD Package)

Construction material:	Package: sapphire base with alumina body and lid. Gold plated molybdenum/manganese metallization on base and lid top with nickel and gold plating. Gold-tin solder hermetic seal. Sensor: zirconium oxy-nitride thin film on sapphire substrate.
Lead material:	Gold (over nickel) e.c. plated Kovar, uninsulated
Polarity:	None
Internal atmosphere:	Package hermetically sealed, partial pressure nitrogen backfill during sealing process
Magnet field effects:	Recommended for magnetic fields. $(\Delta T/T)(\%) < 2$ for $3 \text{ K} < T < 425 \text{ K}$ and $B \leq 20$ tesla (see attached graphs)
Radiation effects:	Recommended. See attached graphs
ESD sensitivity:	Not applicable

Note: Consult factory for special operation or packaging/modifications. These can include:

- Pre-bake at high temperatures for high temperature conditioning and operation
- Bare chip with gold leads
- Extension wire
- SD package with phosphor bronze leads (soldered)
- SD package with platinum ribbon leads (welded)

Cernox[™] Temperature Sensor Response Curves

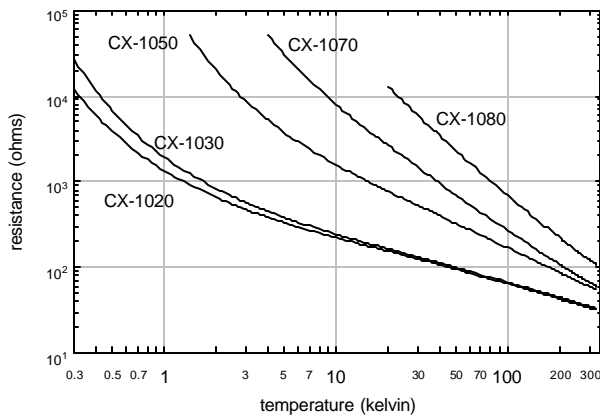


Figure 1. Typical resistance versus temperature response for the Cernox[™] family of resistance temperature sensors.

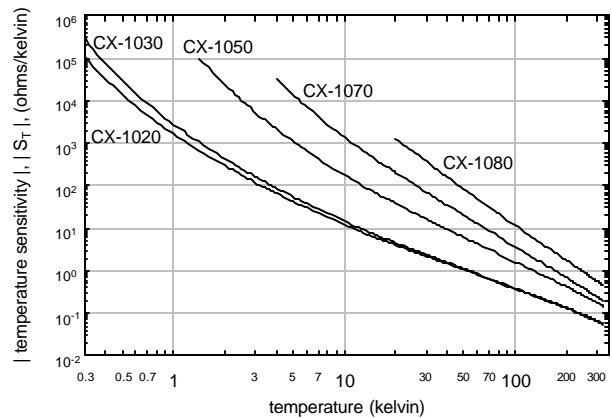


Figure 2. Typical temperature sensitivity (S_T) versus temperature response for the Cernox[™] family of resistance temperature sensors.

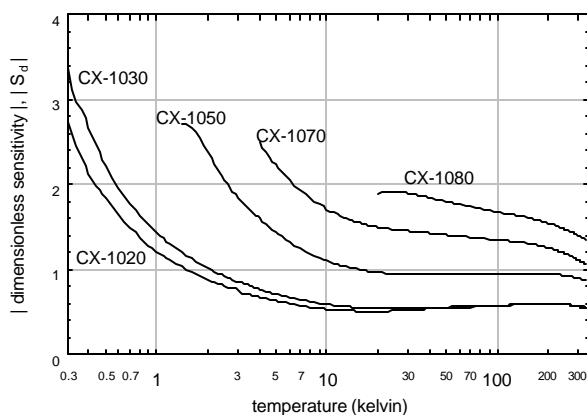


Figure 3. Typical dimensionless sensitivity (S_d) versus temperature response for the Cernox[™] family of resistance temperature sensors.

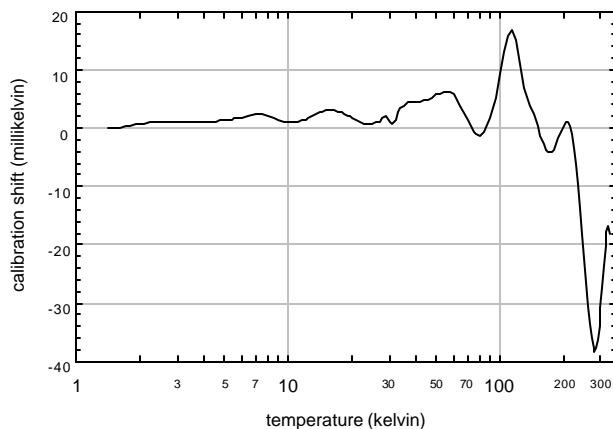


Figure 4. Typical repeatability of a CX-1050 after 200 thermal shocks from room temperature to 77 K.

Calibration Offsets Induced by High Level Radiation Cernox[®] Resistance Temperature Sensors

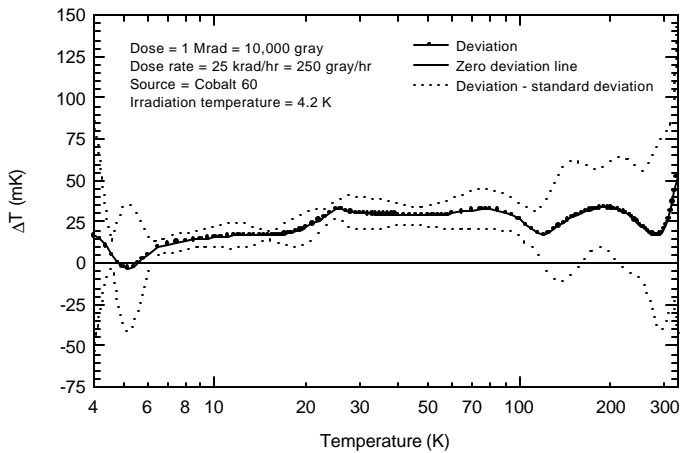


Figure 4. Average temperature calibration shift for 15 Cernox[™] resistance temperature sensors caused by 1 Mrad (10,000 gray) gamma radiation (Si) from a cobalt-60 source. Dose rate: 25 krads/hour (250 gray/hour). Irradiation temperature: 4.2 K.

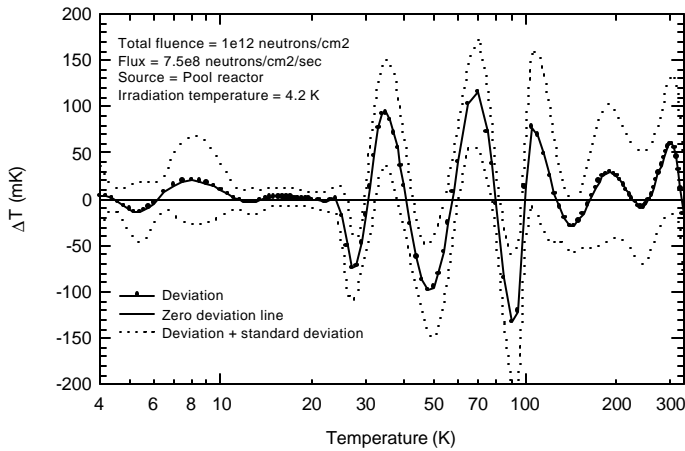


Figure 5. Average temperature calibration shift for 15 Cernox[™] resistance temperature sensors caused by a total fluence of 10^{12} neutrons/cm² from a pool reactor. Flux: 7.5×10^8 neutrons/cm²/s. Irradiation temperature: 4.2 K.

Magnetic Field-Induced Calibration Offsets for CX-1030/1050 Series Cernox[®] Resistance Temperature Sensors

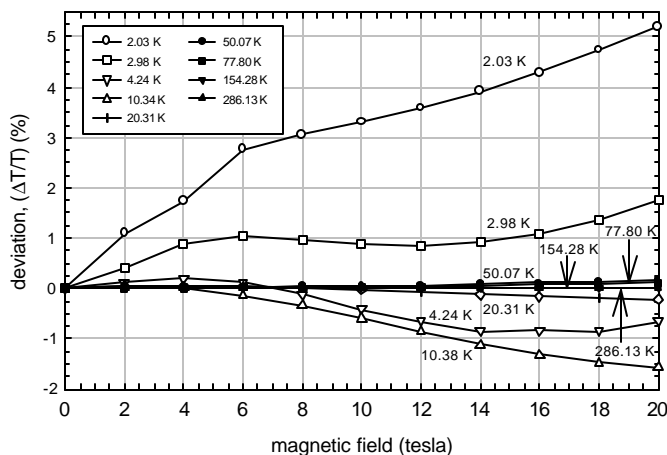


Figure 6. Magnetic field induced temperature error ($\Delta T/T$)(%) for Cernox CX-1030/1050 series resistance temperature sensors.

Resistance and Sensitivity at Selected Temperatures for Cernox™

T (kelvin)	Cernox Model									
	CX-1020		CX-1030		CX-1050		CX-1070		CX-1080	
	R (Ω)	S _T (Ω/K)	R (Ω)	S _T (Ω/K)	R (Ω)	S _T (Ω/K)	R (Ω)	S _T (Ω/K)	R (Ω)	S _T (Ω/K)
0.3	12,003	109,306	27,172	-306,120	—	—	—	—	—	—
0.5	3,851	14,267	6,705	-29,846	—	—	—	—	—	—
0.75	1,982	3,795	3,044	-6,940	—	—	—	—	—	—
1	1,355	1,651	1,938	-2,790	—	—	—	—	—	—
1.4	929	687	1,245	-1,071	51,341	-99,945	—	—	—	—
2	660	292	839	-429	20,300	-24,190	—	—	—	—
3	473	120	573	-164	8,677	-5,360	—	—	—	—
4.2	373	59.6	436	-78.9	4,894	-1,823	46,265	-26,823	—	—
6	297	30	338	-38.2	2,927	-648	20,833	-7,158	—	—
10	222	12	245	-14.5	1,582	-175	8,017	-1,373	—	—
15	180	6.2	194	-7.2	1,032	-69.5	4,139	-431	—	—
20	155	4.1	166	-4.5	777	-37.6	2,666	-200	12,926	-1,229
30	125	2.2	133	-2.4	527	-16.7	1,466	-71.1	5,950	-377
40	107	1.5	113	-1.6	402	-9.5	967	-34.6	3,471	-160
50	95.6	1.1	99.7	-1.1	325	-6.1	704	-19.9	2,309	-83.4
60	86.4	0.8	90	-0.84	274	-4.3	545	-12.7	1,667	-49.2
77.35	75	0.5	77.9	-0.57	216	-2.6	383	-6.82	1,069	-23.8
100	64.7	0.4	67.3	-0.39	169	-1.6	270	-3.66	690	-11.6
150	51.1	0.2	53.1	-0.21	115	-0.74	157	-1.38	354	-3.81
200	42.9	0.13	44.7	-0.14	87.4	-0.43	109	-0.68	224	-1.74
250	37.5	0.09	39.1	-0.093	70.8	-0.26	83.5	-0.39	160	-0.95
273	35.6	0.08	37.1	-79	65.2	-0.22	74.4	-0.32	140	-0.74
300	33.7	0.06	35.1	-67	59.9	-0.18	66.8	-0.25	123	-0.57
325	32.2	0.05	33.6	-0.058	55.7	-0.15	61.2	-0.2	110	-0.46

Nominal Excitation: 10 mV for 1.4 K < T < 330 K
 0.1 mV for 0.3 < T < 1.4 K (AC resistance bridge recommended)

Table 1. Resistance and sensitivity at selected temperatures for Cernox™ Resistance Temperature Sensors.

DT-470-SD Silicon Diode Sensor

Technical Data

Lake Shore DT-470-SD Silicon Diode Temperature sensors (400 series) are ideally suited to the detection and measurement of cryogenic temperatures in space applications. The sensor response is monotonic over the entire useful range and follows a typical response curve (see Fig. 1). Sensors are available in five tolerance bands about this curve, allowing interchangeability among devices. The sensors can be individually calibrated for applications requiring higher accuracy temperature measurements. Calibrations are performed in the Lake Shore temperature sensor calibration facility. The Lake Shore calibration facility and procedures for diode and resistance sensor calibrations above 1.2 K are maintained traceable in accordance with MIL-STD-45662A.

Specification:

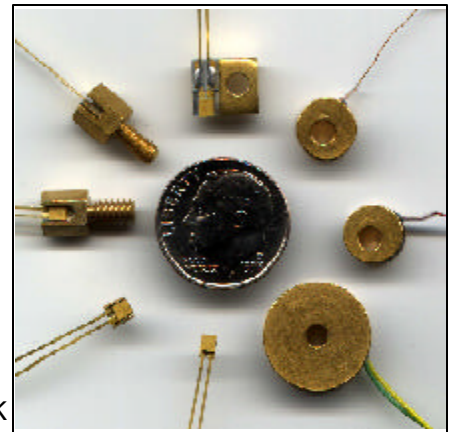
Stress above the absolute maximum rating may cause permanent damage to the device. Extended operation at the maximum levels may degrade performance and affect reliability.

Absolute maximum rating:

Maximum reverse voltage (V_R):	40 V
Maximum forward current (I_F):	500 μ A
Maximum soldering temperature:	200 °C
Maximum storage temperature range:	1.4 K to 475 K

Recommended operating conditions:

Operating temperature range:	1.4 K to 475 K
Excitation current (I_F):	10 μ A \pm 0.05%
Accuracy (calibrated):	\pm 20 mK < 10 K, \pm 25 mK at 20 K \pm 55 mK at 50 K, \pm 50 mK at 300 K
Accuracy (interchangeability)	See Table 2.
Dissipation at rated excitation:	16 μ W at 4.2 K
Units range:	0 to 2 V
Recommended recalibration schedule:	Annual
Thermal response time:	Typical < 10 ms at 4.2 K; 100 ms at 77 K; 200 ms at 305 K



Stability:

Short term:	\pm 5 mK or better at 4.2 K; \pm 20 mK (1.4 K to 330 K); \pm 15 mK or better (above 330 K)
Long term (per year):	\pm 10 mK at 4.2 K \pm 40 mK at 77 K \pm 25 mK at 300 K

Physical Specification: (SD Package)

Construction material:	Sapphire base with alumina body and lid. Gold plated molybdenum/manganese metallization on base and lid top with nickel and gold plating. Gold-tin solder as hermetic seal. Silicon chip with aluminum metallization.
Lead material:	Gold (over Nickel) Plated Kovar, uninsulated
Polarity:	Anode lead is identified as the lead on the right with package lid up and leads toward user (observer)
Internal atmosphere:	Package hermetically sealed, N ₂ partial pressure backfill
* Other packaging available - consult factory	
Radiation effects:	See attached graphs
ESD sensitivity:	3000 static volts or greater

DT-470-SD Silicon Diode Temperature response curve

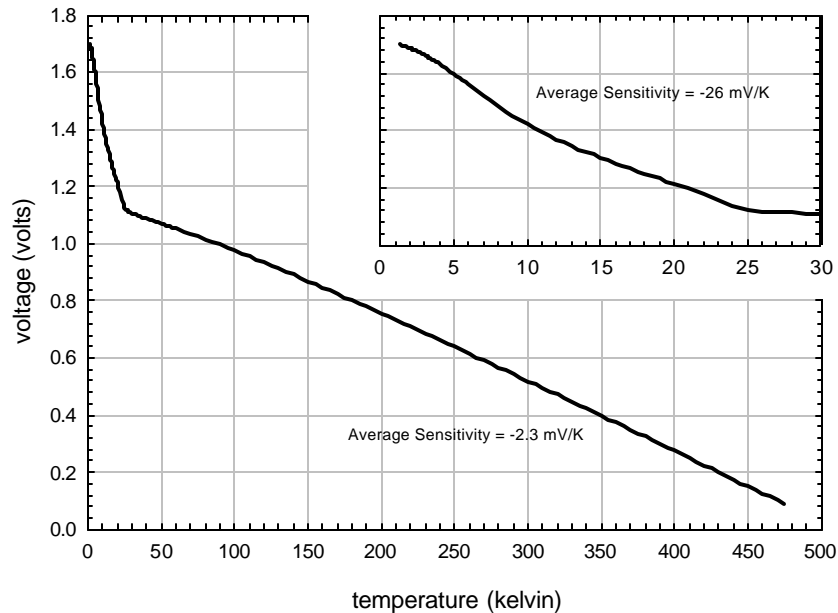


Figure 7. Typical temperature response curve for the DT-470 series diode temperature sensor. Constant current excitation: $10 \mu\text{A} \pm 0.05\%$.

Standard Curve 10 Tolerance Bands			
Band	2 K - 100 K	100 K - 305 K	305 K - 475 K
11	$\pm 0.25 \text{ K}$	$\pm 0.5 \text{ K}$	$\pm 1.0 \text{ K}$
11A	$\pm 0.25 \text{ K}$	$\pm 1\% \text{ of temp.}$	$\pm 1\% \text{ of temp.}$
12	$\pm 0.5 \text{ K}$	$\pm 1.0 \text{ K}$	$\pm 2.0 \text{ K}$
12A	$\pm 0.5 \text{ K}$	$\pm 1\% \text{ of temp.}$	$\pm 1\% \text{ of temp.}$
13	$\pm 1.0 \text{ K}$	$\pm 1\% \text{ of temperature}$	

Table 2. DT-470 Silicon Diode tolerance bands relative to Curve 10.

T (kelvin)	Voltage (volts)	Sensitivity (mV/K)	T (kelvin)	Voltage (volts)	Sensitivity (mV/K)
1.4	1.69812	-13.1	77.35	1.02032	-1.92
2	1.68786	-20.7	100	0.9755	-2.04
3	1.66292	-28.1	150	0.86873	-2.21
4.2	1.62602	-33.6	200	0.75554	-2.31
6	1.56027	-38.4	250	0.63841	-2.37
10	1.42013	-28.7	273	0.58327	-2.39
15	1.30422	-19.4	300	0.51892	-2.4
20	1.2144	-17.6	350	0.39783	-2.44
30	1.10702	-2.34	400	0.27456	-2.49
40	1.08781	-1.74	450	0.14985	-2.46
50	1.07053	-1.75	475	0.09062	-2.22

Table 3. Voltage and sensitivity at selected temperatures for the DT-470 series diode temperature sensor. Constant current excitation: $10 \mu\text{A} \pm 0.05\%$.

Calibration offsets induced by low dose gamma radiation for the DT-400 series diode temperature sensor

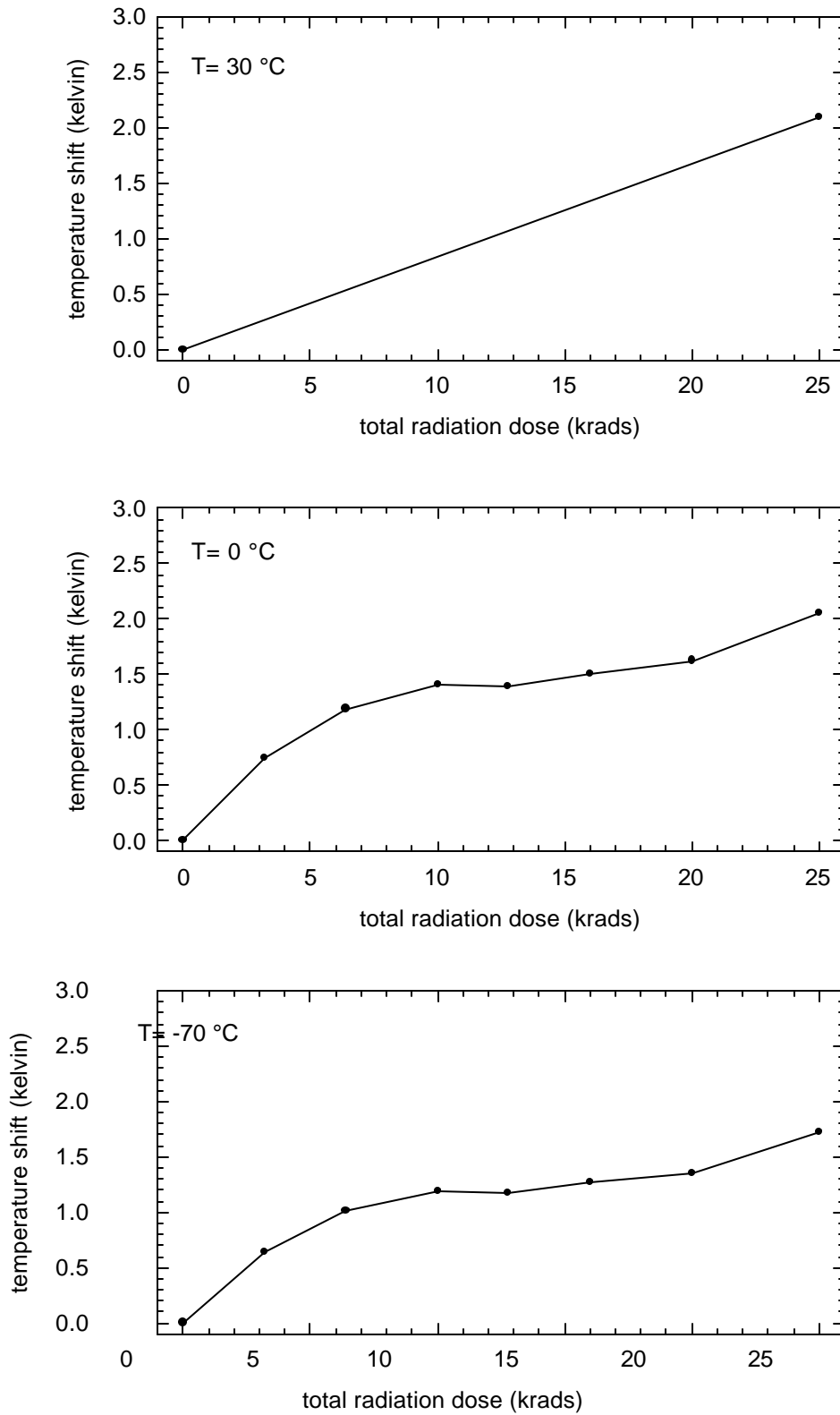


Figure 8. Low-level gamma radiation induced temperature offsets for the four sample DT-400 series temperature sensors. Gamma source: cobalt-60. Dose rate: 100 rad/s = 1 gray/s (Si). Irradiation temperature: 298 K.

Calibration offsets induced by high dose gamma radiation for the DT-400 series diode temperature sensor

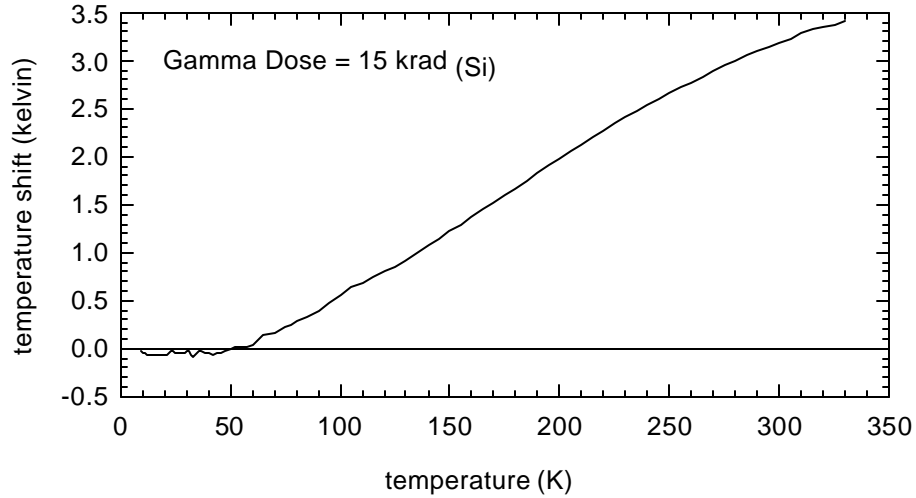


Figure 9. Temperature calibration shift caused by 15 krads (0.15 gray) gamma radiation (Si) from a cesium-137 source. Dose rate: 50 rads/min. Irradiation temperature: 298 K.

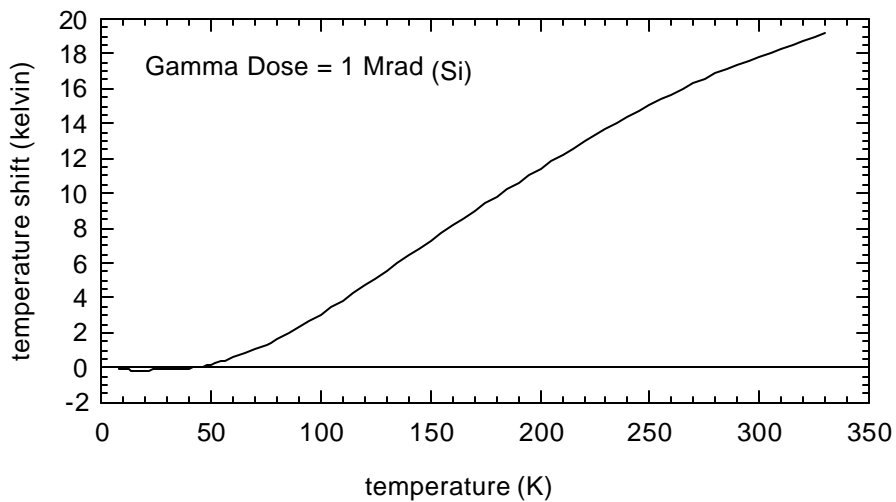


Figure 10. Temperature calibration shift caused by 1 Mrad (10,000 gray) gamma radiation (Si) from a cesium-137 source. Dose rate: 50 rad/min. Irradiation temperature: 298 K.

**SD Package for the Cernox™ and DT-400 Series
Silicon Diode Temperature Sensor**

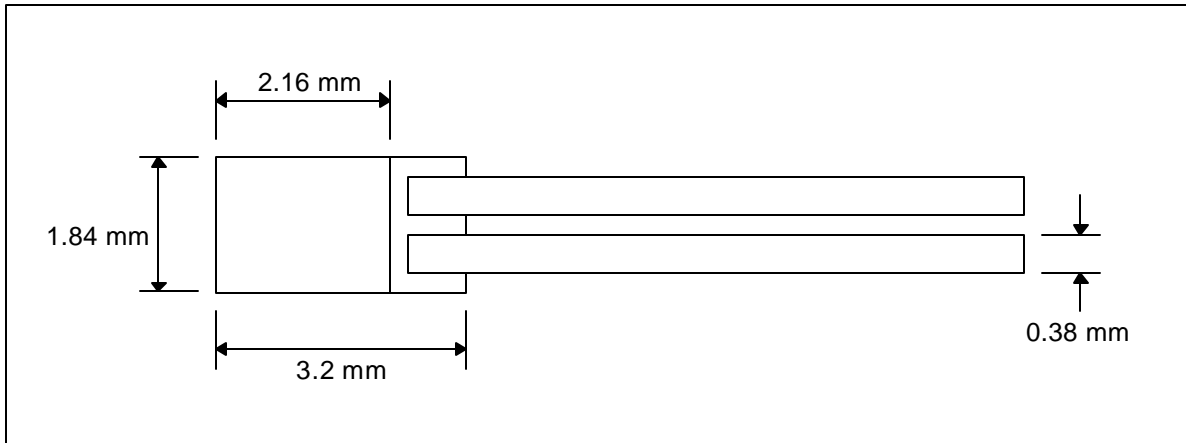


Figure 11. Cernox™ and DT-470-SD hermetic package, top view.

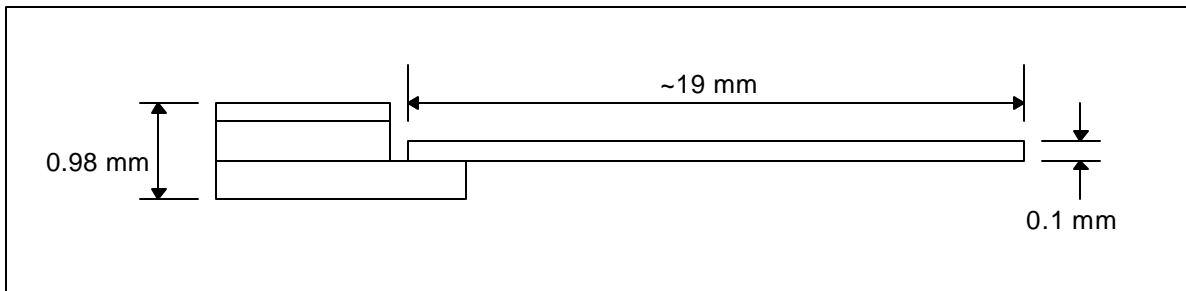


Figure 12. Cernox™ and DT-470-SD hermetic package, side view.

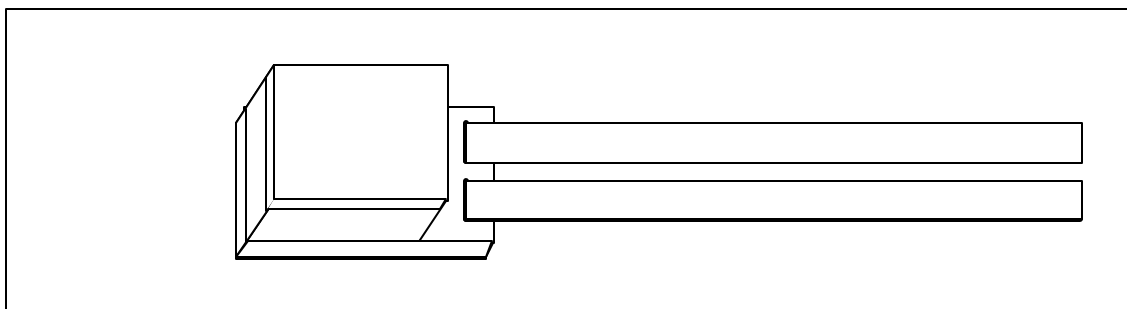


Figure 13. Cernox™ and DT-470-SD hermetic package, 3-dimensional view