

Certificate of Calibration
Report Number: 13261A58

Sensor Model: CX-1050-AA-1.4L	Serial Number: X182092
Sensor Type: Cernox Resistor	Calibration Date: June 06, 2022
Sensor Excitation: see <i>Test Data</i> page of report	Calibration Due:
Temperature Range: 1.40 K to 325 K	

Traceability and Calibration Method

This temperature sensor has been calibrated to the International Temperature Scale of 1990 (ITS-90) or the Provisional Low Temperature Scale (PLTS-2000) as appropriate. The calibrations are traceable to the National Institute of Standards and Technology (NIST, United States), the National Physical Laboratory (NPL, United Kingdom), the Physikalisch-Technische Bundesanstalt (PTB, Germany), or natural physical constants.

Lake Shore Cryotronics maintains ITS-90 and PLTS-2000 on standard platinum (PRT), rhodium-iron (RIRT), and germanium (GRT) resistance thermometers that have been calibrated directly by an internationally recognized national metrology institute (NIST, NPL, PTB) for $T < 330$ K or an ISO 17025 accredited metrology laboratory for $330 \text{ K} < T < 800$ K. A nuclear orientation thermometer is also used for temperatures less than 50 mK. These standards are routinely intercompared to verify consistency and accuracy of the temperature scale.

The sensor calibrations are performed by comparison to laboratory standard resistance thermometers and tested in accordance with Lake Shore Cryotronics, Inc. Quality Assurance Manual (QP-4220). The quality system of Lake Shore Cryotronics is registered to ISO 9001.

Procedures used: 021-97-02, 099-00-00, 121-96-02, 029-95-02

Notes

The calibration results in this report apply only to the specific sensor specified above.

This report shall not be reproduced, except in full, without written approval from Lake Shore Cryotronics, Inc.

Unless stated otherwise, the uncertainties in this report are based on an approximate 95% confidence level with a coverage factor $k=2$.

Reported by: Matt Chih
Calibration
Engineer/Technician

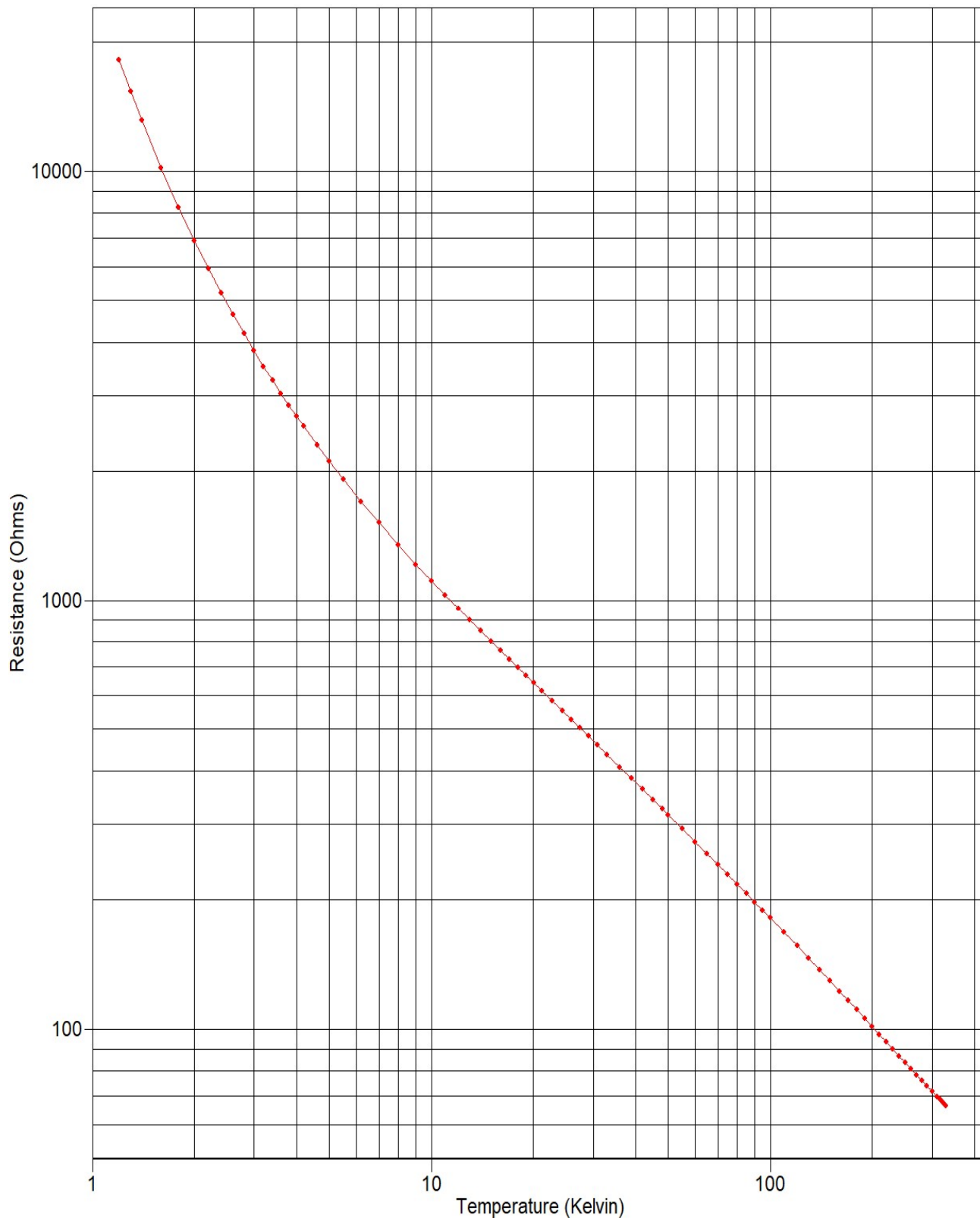
Approved by: Kristine Shiffman
Metrology



DATA PLOT

Calibration Report: 13261A58
Sensor Model: CX-1050-AA-1.4L
Sensor Type: Cernox Resistor

Serial Number: X182092
Temperature Range: 1.40 K to 325 K



TEST DATA

Calibration Report: 13261A58

Sensor Model: CX-1050-AA-1.4L

Sensor Type: Cernox Resistor

Serial Number: X182092

Temperature Range: 1.40 K to 325 K

Index	Temp. (K)	Resistance (Ω)	Excitation	Index	Temp. (K)	Resistance (Ω)	Excitation
1	1.19917	18203.3	2mV $\pm$ 25%	46	41.9923	361.753	2mV $\pm$ 25%
2	1.29938	15326.1	2mV $\pm$ 25%	47	44.9849	342.790	2mV $\pm$ 25%
3	1.39976	13152.0	2mV $\pm$ 25%	48	47.9870	325.834	2mV $\pm$ 25%
4	1.59694	10177.1	2mV $\pm$ 25%	49	49.9815	315.594	2mV $\pm$ 25%
5	1.79927	8217.63	2mV $\pm$ 25%	50	54.9825	292.756	2mV $\pm$ 25%
6	2.00016	6884.42	2mV $\pm$ 25%	51	59.9776	273.319	2mV $\pm$ 25%
7	2.20087	5919.79	2mV $\pm$ 25%	52	64.9691	256.545	2mV $\pm$ 25%
8	2.40068	5194.14	2mV $\pm$ 25%	53	69.9581	241.896	2mV $\pm$ 25%
9	2.60101	4629.69	2mV $\pm$ 25%	54	74.9465	228.974	2mV $\pm$ 25%
10	2.79985	4182.20	2mV $\pm$ 25%	55	79.9458	217.450	2mV $\pm$ 25%
11	3.00023	3816.12	2mV $\pm$ 25%	56	84.9449	207.088	2mV $\pm$ 25%
12	3.20222	3510.05	2mV $\pm$ 25%	57	89.9403	197.757	2mV $\pm$ 25%
13	3.40288	3254.62	2mV $\pm$ 25%	58	94.9386	189.266	2mV $\pm$ 25%
14	3.60295	3037.54	2mV $\pm$ 25%	59	99.9352	181.530	2mV $\pm$ 25%
15	3.80295	2850.22	2mV $\pm$ 25%	60	109.915	167.904	2mV $\pm$ 25%
16	4.00293	2686.75	2mV $\pm$ 25%	61	119.923	156.240	2mV $\pm$ 25%
17	4.20287	2543.37	2mV $\pm$ 25%	62	129.912	146.146	2mV $\pm$ 25%
18	4.60185	2302.85	2mV $\pm$ 25%	63	139.897	137.339	2mV $\pm$ 25%
19	5.00222	2108.56	2mV $\pm$ 25%	64	149.900	129.554	2mV $\pm$ 25%
20	5.49973	1914.17	2mV $\pm$ 25%	65	159.903	122.632	2mV $\pm$ 25%
21	6.20029	1702.23	2mV $\pm$ 25%	66	169.902	116.435	2mV $\pm$ 25%
22	7.00553	1518.04	2mV $\pm$ 25%	67	179.896	110.868	2mV $\pm$ 25%
23	8.00214	1346.25	2mV $\pm$ 25%	68	189.891	105.836	2mV $\pm$ 25%
24	9.00597	1214.66	2mV $\pm$ 25%	69	199.887	101.265	2mV $\pm$ 25%
25	10.0031	1111.40	2mV $\pm$ 25%	70	209.887	97.0941	2mV $\pm$ 25%
26	11.0012	1027.20	2mV $\pm$ 25%	71	219.889	93.2831	2mV $\pm$ 25%
27	11.9997	957.099	2mV $\pm$ 25%	72	229.892	89.7878	2mV $\pm$ 25%
28	12.9996	897.582	2mV $\pm$ 25%	73	239.892	86.5618	2mV $\pm$ 25%
29	14.0011	846.343	2mV $\pm$ 25%	74	249.885	83.5962	2mV $\pm$ 25%
30	15.0001	801.769	2mV $\pm$ 25%	75	259.894	80.8377	2mV $\pm$ 25%
31	15.9994	762.395	2mV $\pm$ 25%	76	269.904	78.2832	2mV $\pm$ 25%
32	17.0012	727.320	2mV $\pm$ 25%	77	279.905	75.9154	2mV $\pm$ 25%
33	17.9985	695.956	2mV $\pm$ 25%	78	289.907	73.7029	2mV $\pm$ 25%
34	19.0003	667.509	2mV $\pm$ 25%	79	299.914	71.6454	2mV $\pm$ 25%
35	20.0872	639.541	2mV $\pm$ 25%	80	309.929	69.7190	2mV $\pm$ 25%
36	21.1535	614.619	2mV $\pm$ 25%	81	314.953	68.7928	2mV $\pm$ 25%
37	22.7214	581.798	2mV $\pm$ 25%	82	319.966	67.9014	2mV $\pm$ 25%
38	24.3251	552.129	2mV $\pm$ 25%	83	325.960	66.8633	2mV $\pm$ 25%
39	25.9098	526.005	2mV $\pm$ 25%	84	329.974	66.1910	2mV $\pm$ 25%
40	27.4972	502.469	2mV $\pm$ 25%				
41	29.0947	481.080	2mV $\pm$ 25%				
42	30.9016	459.195	2mV $\pm$ 25%				
43	32.9948	436.461	2mV $\pm$ 25%				
44	35.9942	407.958	2mV $\pm$ 25%				
45	38.9945	383.281	2mV $\pm$ 25%				

UNCERTAINTY ANALYSIS

Calibration Report: 13261A58

Sensor Model: CX-1050-AA-1.4L

Sensor Type: Cernox Resistor

Serial Number: X182092

Temperature Range: 1.40 K to 325 K

Calibration Data Uncertainty

The uncertainties of the measured calibration data for Lake Shore's sensors are summarized in the table below. The values given are the combined uncertainty of the temperature measurement and the resistance or voltage measurement expressed as an equivalent temperature uncertainty in millikelvin (mK). Note that the values are the calibration uncertainty only and do not include the stability of the temperature sensor. The uncertainty analysis has followed the guidelines for determining measurement uncertainty as outlined in the ISO Guide to the Expression of Uncertainty in Measurement, NIST Technical Note 1297, and ANSI/NCSS Z540-2-1997. Since the uncertainty varies with temperature due to the variation of the sensor sensitivity and excitation, the table gives typical values at several different temperatures throughout the range of the calibration. The uncertainty is based on an approximate 95% confidence level with a coverage factor $k = 2$.

T (K)	Uncertainty ($\pm$ mK)												
	GR	Cernox (CX)					RX			Platinum		RF-800	Diode
		1010	1030	1050	1070	1080	102A	103A	202A	100 Ω	25 Ω	27 Ω	
1.4	4	4	4	4			4	4	4			5	7
4.2	4	4	4	4	4		4	6	5			5	5
10	4	5	5	4	4		10	15	12			7	6
20	8	10	9	8	8	8	35	35	28	9	10	13	9
30	9	13	11	9	9	9	76	61	46	9	9	14	31
50	11	18	14	12	12	11				10	10	13	37
100	20	29	22	17	16	14				11	12	12	32
300		78	60	46	45	36				24	24	25	35
400		124	94	74	72	60				45	45	45	49
500										51	51		54

Polynomial Fit Uncertainty

When a sensor is used to measure temperature, a polynomial fit to the measured calibration data is often used to convert the sensor resistance (R) or voltage (V) to a temperature (T). How well the polynomial represents the sensor calibration data is another source of uncertainty when using the sensor. In the polynomials provided with this set of calibration data, the standard deviation of the fit can be used as an estimate of this additional temperature uncertainty. The standard deviation of fit is determined from the following equation:

$$\sigma_{fit}^2 = \frac{\sum_{i=1}^N (T_i - T_{icalc})^2}{N - n} = \frac{N}{N - n} (\Delta T_{RMS})^2$$

where

σ_{fit} = standard deviation of the fit

T_i = measured temperature for point i

T_{icalc} = the temperature calculated from the polynomial equation for point i

N = number of data points in fit range

n = number of fit coefficients

ΔT_{RMS} = root mean square deviation of fit

A value of ΔT_{RMS} is given for each range of fit.

F008-04-00_C



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POLYNOMIAL EQUATION

Calibration Report: 13261A58

Sensor Model: CX-1050-AA-1.4L

Sensor Type: Cernox Resistor

Serial Number: X182092

Temperature Range: 1.40 K to 325 K

Polynomial Type: Chebychev

Useful Range of Fit:

1.40 K to 14.0 K
1.314e+4 ohms to 846.3 ohms

Lower and Upper limits of Log(Resistance) used in computing Chebychev coefficients:

ZL = 2.8821798407

ZU = 4.26015088995

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	5.544728	9.9928E-05	55487.44
1	-6.357782	1.6033E-04	-39654.30
2	2.761894	1.4094E-04	19596.48
3	-0.977378	1.4489E-04	-6745.84
4	0.284274	1.3742E-04	2068.72
5	-0.065515	1.2735E-04	-514.43
6	0.009535	1.2524E-04	76.14
7	0.000249	1.2507E-04	1.99
8	-0.000921	1.2659E-04	-7.27

$Z = \text{Log}(\text{Resistance})$

$k = ((Z - ZL) - (ZU - Z)) / (ZU - ZL)$

Temp. (K) = $\sum A_i * \text{COS}(i * \text{ARCCOS}(k))$, where $0 \leq i \leq 8$
and the A_i 's are the coefficients in the table above.

POLYNOMIAL EQUATION

Calibration Report: 13261A58

Sensor Model: CX-1050-AA-1.4L

Sensor Type: Cernox Resistor

Serial Number: X182092

Temperature Range: 1.40 K to 325 K

Polynomial Type: Chebychev

Temp. (K) vs. Log(Resistance)

	R Meas. (Ω)	T Meas. (K)	T Eq. (K)	T diff. (mK)
1	18203.33	1.19917	1.19908	0.08
2	15326.07	1.29938	1.29979	-0.41
3	13151.96	1.39976	1.39921	0.55
4	10177.08	1.59694	1.59707	-0.13
5	8217.630	1.79927	1.79968	-0.41
6	6884.417	2.00016	2.00014	0.02
7	5919.789	2.20087	2.20038	0.49
8	5194.137	2.40068	2.40047	0.21
9	4629.690	2.60101	2.60090	0.11
10	4182.195	2.79985	2.80024	-0.39
11	3816.117	3.00023	3.00045	-0.23
12	3510.053	3.20222	3.20254	-0.32
13	3254.618	3.40288	3.40308	-0.21
14	3037.536	3.60295	3.60288	0.07
15	2850.222	3.80295	3.80266	0.29
16	2686.747	4.00293	4.00272	0.22
17	2543.369	4.20287	4.20230	0.57
18	2302.847	4.60185	4.60171	0.13
19	2108.564	5.00222	5.00243	-0.21
20	1914.168	5.49973	5.50041	-0.68
21	1702.226	6.20029	6.20062	-0.32
22	1518.037	7.00553	7.00479	0.74
23	1346.255	8.00214	8.00230	-0.15
24	1214.656	9.00597	9.00607	-0.10
25	1111.400	10.00312	10.00266	0.46
26	1027.198	11.00125	11.00127	-0.02
27	957.0990	11.99971	12.00002	-0.31
28	897.5825	12.99965	13.00028	-0.63
29	846.3431	14.00106	14.00085	0.21
30	801.7692	15.00015	14.99923	0.92
31	762.3947	15.99942	15.99994	-0.52

Order of Fit = 8 RMS error of fit = 0.40 mK

Largest absolute error = 0.92 mK at data point no. 30

POLYNOMIAL EQUATION

Calibration Report: 13261A58

Sensor Model: CX-1050-AA-1.4L

Sensor Type: Cernox Resistor

Serial Number: X182092

Temperature Range: 1.40 K to 325 K

Polynomial Type: Chebychev

Useful Range of Fit:

14.0 K to 79.9 K
846.3 ohms to 217.4 ohms

Lower and Upper limits of Log(Resistance) used in computing Chebychev coefficients:

ZL = 2.29613261419

ZU = 2.98095687427

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	41.897344	3.3402E-04	125435.34
1	-37.639043	5.4610E-04	-68922.99
2	8.924868	4.9584E-04	17999.49
3	-1.325896	4.6590E-04	-2845.87
4	0.153936	4.4775E-04	343.80
5	-0.006050	4.2996E-04	-14.07
6	-0.006509	4.1879E-04	-15.54
7	0.001031	4.1417E-04	2.49

$Z = \text{Log}(\text{Resistance})$

$k = ((Z-ZL)-(ZU-Z))/(ZU-ZL)$

Temp. (K) = $\sum A_i * \text{COS}(i * \text{ARCCOS}(k))$, where $0 \leq i \leq 7$
and the A_i 's are the coefficients in the table above.

POLYNOMIAL EQUATION

Calibration Report: 13261A58

Sensor Model: CX-1050-AA-1.4L

Sensor Type: Cernox Resistor

Serial Number: X182092

Temperature Range: 1.40 K to 325 K

Polynomial Type: Chebychev

Temp. (K) vs. Log(Resistance)

	R Meas. (Ω)	T Meas. (K)	T Eq. (K)	T diff. (mK)
27	957.0990	12.00002	11.99968	0.34
28	897.5825	13.00028	13.00091	-0.62
29	846.3431	14.00085	14.00143	-0.58
30	801.7692	15.00015	14.99937	0.78
31	762.3947	15.99942	15.99931	0.11
32	727.3197	17.00122	17.00047	0.75
33	695.9557	17.99853	17.99836	0.17
34	667.5089	19.00027	19.00006	0.21
35	639.5411	20.08717	20.08761	-0.45
36	614.6188	21.15351	21.15461	-1.10
37	581.7983	22.72136	22.72242	-1.05
38	552.1289	24.32514	24.32548	-0.34
39	526.0053	25.90975	25.90905	0.70
40	502.4686	27.49722	27.49691	0.32
41	481.0803	29.09474	29.09301	1.73
42	459.1949	30.90164	30.90064	1.01
43	436.4607	32.99483	32.99538	-0.55
44	407.9582	35.99421	35.99422	-0.02
45	383.2810	38.99452	38.99698	-2.46
46	361.7533	41.99232	41.99335	-1.03
47	342.7897	44.98494	44.98362	1.32
48	325.8338	47.98699	47.98866	-1.67
49	315.5937	49.98145	49.97891	2.55
50	292.7560	54.98251	54.98110	1.41
51	273.3188	59.97756	59.97778	-0.22
52	256.5448	64.96914	64.97024	-1.10
53	241.8956	69.95811	69.95998	-1.87
54	228.9740	74.94646	74.94650	-0.03
55	217.4497	79.94579	79.94158	4.20
56	207.0885	84.94485	84.94802	-3.16
57	197.7573	89.94026	89.93960	0.67

Order of Fit = 7 RMS error of fit = 1.42 mK

Largest absolute error = 4.20 mK at data point no. 55

POLYNOMIAL EQUATION

Calibration Report: 13261A58

Sensor Model: CX-1050-AA-1.4L

Sensor Type: Cernox Resistor

Serial Number: X182092

Temperature Range: 1.40 K to 325 K

Polynomial Type: Chebychev

Useful Range of Fit:

79.9 K to 325 K
217.4 ohms to 67.03 ohms

Lower and Upper limits of Log(Resistance) used in computing Chebychev coefficients:

ZL = 1.82079867213

ZU = 2.38362789698

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	176.442064	2.9848E-03	59114.26
1	-126.661588	4.6118E-03	-27464.95
2	22.922836	4.4260E-03	5179.13
3	-3.248458	4.1941E-03	-774.53
4	0.608946	3.9962E-03	152.38
5	-0.115200	4.0090E-03	-28.74
6	0.008803	3.9553E-03	2.23
7	0.006438	3.8200E-03	1.69

$Z = \text{Log}(\text{Resistance})$

$k = ((Z-ZL)-(ZU-Z))/(ZU-ZL)$

Temp. (K) = $\sum A_i * \text{COS}(i * \text{ARCCOS}(k))$, where $0 \leq i \leq 7$
and the A_i 's are the coefficients in the table above.

POLYNOMIAL EQUATION

Calibration Report: 13261A58

Sensor Model: CX-1050-AA-1.4L

Sensor Type: Cernox Resistor

Serial Number: X182092

Temperature Range: 1.40 K to 325 K

Polynomial Type: Chebychev

Temp. (K) vs. Log(Resistance)

	R Meas. (Ω)	T Meas. (K)	T Eq. (K)	T diff. (mK)
53	241.8956	69.95998	69.96384	-3.86
54	228.9740	74.94650	74.94061	5.89
55	217.4497	79.94158	79.93709	4.49
56	207.0885	84.94485	84.94721	-2.35
57	197.7573	89.94026	89.94280	-2.54
58	189.2664	94.93861	94.94573	-7.13
59	181.5299	99.93522	99.93714	-1.92
60	167.9044	109.91488	109.91297	1.90
61	156.2397	119.92290	119.91128	11.62
62	146.1457	129.91207	129.91444	-2.37
63	137.3386	139.89670	139.89679	-0.10
64	129.5543	149.90012	149.89706	3.06
65	122.6316	159.90344	159.90156	1.88
66	116.4345	169.90194	169.91151	-9.57
67	110.8680	179.89571	179.90432	-8.61
68	105.8362	189.89090	189.89373	-2.83
69	101.2654	199.88714	199.88603	1.11
70	97.09414	209.88694	209.88995	-3.00
71	93.28307	219.88884	219.88300	5.84
72	89.78783	229.89181	229.87085	20.96
73	86.56175	239.89244	239.88899	3.45
74	83.59618	249.88536	249.86899	16.37
75	80.83774	259.89444	259.90327	-8.83
76	78.28315	269.90399	269.92486	-20.87
77	75.91539	279.90509	279.91657	-11.48
78	73.70289	289.90743	289.93672	-29.29
79	71.64539	299.91399	299.91473	-0.74
80	69.71900	309.92856	309.89606	32.50
81	68.79283	314.95305	314.93400	19.05
82	67.90141	319.96591	319.93942	26.49
83	66.86325	325.96021	325.97229	-12.08
84	66.19096	329.97440	330.00146	-27.05

Order of Fit = 7 RMS error of fit = 13.39 mK
Largest absolute error = 32.50 mK at data point no. 80

INTERPOLATION TABLE

Calibration Report: 13261A58

Sensor Model: CX-1050-AA-1.4L

Sensor Type: Cernox Resistor

Serial Number: X182092

Temperature Range: 1.40 K to 325 K

Temp (K)	Res. (Ω)	dR/dT (Ω /K)	dlogR/dlogT	Temp (K)	Res. (Ω)	dR/dT (Ω /K)	dlogR/dlogT
1.400	13136.9	-19050	-2.0302	15.50	781.458	-39.333	-0.78016
1.500	11459.1	-14761	-1.9322	16.00	762.369	-37.064	-0.77786
1.600	10142.5	-11746	-1.8529	16.50	744.360	-35.004	-0.77592
1.700	9082.97	-9548.6	-1.7871	17.00	727.335	-33.124	-0.77421
1.800	8215.08	-7885.7	-1.7278	17.50	711.209	-31.405	-0.77274
1.900	7493.20	-6603.8	-1.6745	18.00	695.907	-29.828	-0.77151
2.000	6885.19	-5596.5	-1.6257	18.50	681.360	-28.378	-0.77049
2.100	6367.11	-4793.6	-1.5810	19.00	667.511	-27.040	-0.76966
2.200	5921.36	-4144.2	-1.5397	19.50	654.304	-25.803	-0.76899
2.300	5534.34	-3613.3	-1.5016	20.00	641.693	-24.656	-0.76846
2.400	5195.64	-3174.6	-1.4664	21.00	618.090	-22.599	-0.76780
2.500	4896.99	-2808.9	-1.4340	22.00	596.407	-20.808	-0.76755
2.600	4631.94	-2501.0	-1.4039	23.00	576.401	-19.238	-0.76764
2.700	4395.23	-2240.0	-1.3760	24.00	557.871	-17.850	-0.76794
2.800	4182.68	-2016.8	-1.3501	25.00	540.648	-16.619	-0.76847
2.900	3990.83	-1824.8	-1.3260	26.00	524.590	-15.518	-0.76911
3.000	3816.87	-1658.4	-1.3035	27.00	509.575	-14.529	-0.76985
3.100	3658.43	-1513.5	-1.2825	28.00	495.498	-13.638	-0.77068
3.200	3513.57	-1386.4	-1.2627	29.00	482.270	-12.831	-0.77153
3.300	3380.64	-1274.5	-1.2441	30.00	469.813	-12.096	-0.77242
3.400	3258.24	-1175.5	-1.2266	31.00	458.056	-11.426	-0.77331
3.500	3145.18	-1087.4	-1.2101	32.00	446.941	-10.813	-0.77419
3.600	3040.44	-1008.8	-1.1944	33.00	436.413	-10.250	-0.77509
3.700	2943.15	-938.31	-1.1796	34.00	426.426	-9.7320	-0.77596
3.800	2852.54	-874.92	-1.1655	35.00	416.936	-9.2530	-0.77675
3.900	2767.96	-817.70	-1.1521	36.00	407.907	-8.8106	-0.77758
4.000	2688.83	-765.86	-1.1393	37.00	399.304	-8.4004	-0.77839
4.200	2544.92	-675.97	-1.1156	38.00	391.097	-8.0187	-0.77912
4.400	2417.45	-600.92	-1.0937	39.00	383.258	-7.6638	-0.77986
4.600	2303.77	-537.72	-1.0737	40.00	375.761	-7.3327	-0.78057
4.800	2201.73	-484.07	-1.0553	42.00	361.709	-6.7336	-0.78188
5.000	2109.63	-438.09	-1.0383	44.00	348.778	-6.2074	-0.78309
5.200	2026.07	-398.41	-1.0225	46.00	336.838	-5.7427	-0.78425
5.400	1949.92	-363.91	-1.0078	48.00	325.773	-5.3297	-0.78529
5.600	1880.21	-333.88	-0.99443	50.00	315.489	-4.9616	-0.78633
5.800	1816.13	-307.37	-0.98160	52.00	305.902	-4.6314	-0.78729
6.000	1757.06	-283.91	-0.96950	54.00	296.942	-4.3341	-0.78817
6.500	1627.59	-236.21	-0.94333	56.00	288.546	-4.0662	-0.78916
7.000	1518.99	-199.79	-0.92071	58.00	280.660	-3.8230	-0.79005
7.500	1426.46	-171.43	-0.90133	60.00	273.239	-3.6021	-0.79097
8.000	1346.60	-148.88	-0.88448	65.00	256.452	-3.1303	-0.79341
8.500	1276.85	-130.70	-0.87005	70.00	241.785	-2.7489	-0.79584
9.000	1215.36	-115.77	-0.85728	75.00	228.843	-2.4391	-0.79937
9.500	1160.66	-103.38	-0.84617	77.35	223.262	-2.3125	-0.80119
10.00	1111.65	-92.970	-0.83633	80.00	217.313	-2.1790	-0.80217
10.50	1067.43	-84.143	-0.82769	85.00	206.985	-1.9597	-0.80477
11.00	1027.29	-76.578	-0.81997	90.00	197.656	-1.7765	-0.80889
11.50	990.675	-70.052	-0.81318	95.00	189.179	-1.6184	-0.81269
12.00	957.101	-64.381	-0.80720	100.0	181.437	-1.4815	-0.81654
12.50	926.178	-59.408	-0.80179	105.0	174.335	-1.3618	-0.82018
13.00	897.598	-55.003	-0.79661	110.0	167.795	-1.2565	-0.82371
13.50	871.090	-51.109	-0.79208	115.0	161.750	-1.1634	-0.82715
14.00	846.411	-47.681	-0.78866	120.0	156.144	-1.0806	-0.83046
14.50	823.348	-44.621	-0.78582	125.0	150.929	-1.0066	-0.83367
15.00	801.743	-41.846	-0.78290	130.0	146.065	-0.94015	-0.83675

INTERPOLATION TABLE

Calibration Report: 13261A58

Sensor Model: CX-1050-AA-1.4L

Sensor Type: Cernox Resistor

Serial Number: X182092

Temperature Range: 1.40 K to 325 K

<u>Temp (K)</u>	<u>Res. (Ω)</u>	<u>dR/dT (Ω/K)</u>	<u>dlogR/dlogT</u>	<u>Temp (K)</u>	<u>Res. (Ω)</u>	<u>dR/dT (Ω/K)</u>	<u>dlogR/dlogT</u>
135.0	141.517	-0.88025	-0.83972	235.0	88.1031	-0.32158	-0.85776
140.0	137.253	-0.82601	-0.84254	240.0	86.5275	-0.30882	-0.85656
145.0	133.248	-0.77672	-0.84522	245.0	85.0138	-0.29676	-0.85522
150.0	129.479	-0.73175	-0.84772	250.0	83.5588	-0.28536	-0.85376
155.0	125.925	-0.69060	-0.85005	255.0	82.1592	-0.27457	-0.85218
160.0	122.567	-0.65281	-0.85219	260.0	80.8122	-0.26435	-0.85049
165.0	119.391	-0.61802	-0.85411	265.0	79.5149	-0.25466	-0.84872
170.0	116.383	-0.58590	-0.85582	270.0	78.2647	-0.24548	-0.84686
175.0	113.528	-0.55617	-0.85731	273.15	77.5002	-0.23994	-0.84566
180.0	110.817	-0.52858	-0.85856	275.0	77.0593	-0.23676	-0.84494
185.0	108.239	-0.50292	-0.85958	280.0	75.8963	-0.22849	-0.84295
190.0	105.785	-0.47902	-0.86037	285.0	74.7737	-0.22063	-0.84092
195.0	103.447	-0.45672	-0.86093	290.0	73.6894	-0.21315	-0.83885
200.0	101.216	-0.43586	-0.86125	295.0	72.6416	-0.20604	-0.83675
205.0	99.0857	-0.41633	-0.86136	300.0	71.6284	-0.19928	-0.83462
210.0	97.0503	-0.39802	-0.86124	305.0	70.6483	-0.19283	-0.83248
215.0	95.1037	-0.38082	-0.86092	310.0	69.6996	-0.18669	-0.83033
220.0	93.2404	-0.36465	-0.86040	315.0	68.7809	-0.18083	-0.82818
225.0	91.4555	-0.34944	-0.85969	320.0	67.8908	-0.17525	-0.82603
230.0	89.7445	-0.33510	-0.85881	325.0	67.0280	-0.16992	-0.82389

THERMAL CYCLE TESTING

Calibration Report: 13261A58

Sensor Model: CX-1050-AA-1.4L

Sensor Type: Cernox Resistor

Serial Number: X182092

This sensor was tested for repeatability through rapid thermal cycles from room temperature into liquid helium. During this test, the following four lead resistance values were recorded:

Approximately 295 K:	72.0 Ω
Liquid Nitrogen:	223 Ω
Liquid Helium:	2539 Ω

The nitrogen and helium values were recorded in OPEN dewars, so precision comparisons with calibration values or other thermal cycle test values should not be made.

Recommended Operating Parameters:

For sensors calibrated by Lake Shore, the current to the sensor is adjusted to maintain the sensor output voltage or power at the values listed on the Test Data page.

BREAKPOINTS CUBIC SPLINE FORMAT

Calibration Report: 13261A58

Sensor Model: CX-1050-AA-1.4L

Sensor Type: Cernox Resistor

Serial Number: X182092

Temperature Range: 1.40 K to 325 K

Sensor Model: CX-1050-AA-1.4L
Serial Number: X182092
Data Format: 7 (Ohms/Kelvin)
Setpoint Limit: 325

Measurement (ohms)	Temp (K)	Curvature	Measurement (ohms)	Temp (K)	Curvature
6.61910E+01	3.30001E+02	2.21800E-01	8.46343E+02	1.40009E+01	6.03118E-05
6.68633E+01	3.25972E+02	2.14215E-01	8.97582E+02	1.30003E+01	4.91235E-05
6.79014E+01	3.19939E+02	2.02503E-01	9.57099E+02	1.20000E+01	3.95554E-05
6.87928E+01	3.14934E+02	1.93230E-01	1.02720E+03	1.10013E+01	3.10087E-05
6.97190E+01	3.09896E+02	1.83952E-01	1.11140E+03	1.00027E+01	2.36038E-05
7.16454E+01	2.99915E+02	1.66548E-01	1.21466E+03	9.00607E+00	1.73004E-05
7.37029E+01	2.89937E+02	1.50248E-01	1.34625E+03	8.00230E+00	1.20215E-05
7.59154E+01	2.79917E+02	1.34906E-01	1.51804E+03	7.00479E+00	7.87706E-06
7.82832E+01	2.69925E+02	1.20653E-01	1.70223E+03	6.20062E+00	5.27685E-06
8.08377E+01	2.59903E+02	1.07389E-01	1.91417E+03	5.50041E+00	3.50077E-06
8.35962E+01	2.49869E+02	9.51389E-02	2.10856E+03	5.00243E+00	2.51536E-06
8.65618E+01	2.39889E+02	8.39538E-02	2.30285E+03	4.60171E+00	1.84779E-06
8.97878E+01	2.29871E+02	7.37034E-02	2.54337E+03	4.20230E+00	1.31460E-06
9.32831E+01	2.19883E+02	6.44281E-02	2.68675E+03	4.00272E+00	1.09900E-06
9.70941E+01	2.09890E+02	5.60500E-02	2.85022E+03	3.80266E+00	8.96072E-07
1.01265E+02	1.99886E+02	4.85228E-02	3.03754E+03	3.60288E+00	7.22764E-07
1.05836E+02	1.89894E+02	4.18109E-02	3.25462E+03	3.40308E+00	5.72680E-07
1.10868E+02	1.79904E+02	3.58492E-02	3.51005E+03	3.20254E+00	4.44770E-07
1.16435E+02	1.69912E+02	3.05731E-02	3.81612E+03	3.00045E+00	3.36942E-07
1.22632E+02	1.59902E+02	2.59140E-02	4.18220E+03	2.80024E+00	2.49160E-07
1.29554E+02	1.49897E+02	2.18193E-02	4.62969E+03	2.60090E+00	1.78588E-07
1.37339E+02	1.39897E+02	1.82251E-02	5.19414E+03	2.40047E+00	1.22806E-07
1.46146E+02	1.29914E+02	1.50754E-02	5.91979E+03	2.20038E+00	8.04593E-08
1.56240E+02	1.19911E+02	1.23094E-02	6.88442E+03	2.00014E+00	4.95928E-08
1.67904E+02	1.09913E+02	9.88569E-03	8.21763E+03	1.79968E+00	2.83666E-08
1.81530E+02	9.99371E+01	7.80808E-03	1.01771E+04	1.59707E+00	1.47159E-08
1.89266E+02	9.49457E+01	6.91299E-03	1.31520E+04	1.39921E+00	6.90381E-09
1.97757E+02	8.99428E+01	6.01598E-03	1.53261E+04	1.29979E+00	4.50700E-09
2.07088E+02	8.49472E+01	5.34738E-03	1.82033E+04	1.19908E+00	1.33499E-09
2.17450E+02	7.99416E+01	4.51596E-03			
2.28974E+02	7.49465E+01	3.90059E-03			
2.41896E+02	6.99600E+01	3.28647E-03			
2.56545E+02	6.49702E+01	2.73896E-03			
2.73319E+02	5.99778E+01	2.24285E-03			
2.92756E+02	5.49811E+01	1.80068E-03			
3.15594E+02	4.99789E+01	1.41752E-03			
3.25834E+02	4.79887E+01	1.28380E-03			
3.42790E+02	4.49836E+01	1.08773E-03			
3.61753E+02	4.19934E+01	9.14307E-04			
3.83281E+02	3.89970E+01	7.58167E-04			
4.07958E+02	3.59942E+01	6.19414E-04			
4.36461E+02	3.29954E+01	4.98883E-04			
4.59195E+02	3.09006E+01	4.24917E-04			
4.81080E+02	2.90930E+01	3.66205E-04			
5.02469E+02	2.74969E+01	3.18925E-04			
5.26005E+02	2.59091E+01	2.75701E-04			
5.52129E+02	2.43255E+01	2.36416E-04			
5.81798E+02	2.27224E+01	2.00249E-04			
6.14619E+02	2.11546E+01	1.68490E-04			
6.39541E+02	2.00876E+01	1.48737E-04			
6.67509E+02	1.90001E+01	1.29788E-04			
6.95956E+02	1.79984E+01	1.13656E-04			
7.27320E+02	1.70005E+01	9.85718E-05			
7.62395E+02	1.59993E+01	8.48239E-05			
8.01769E+02	1.49994E+01	7.11012E-05			

BREAKPOINTS 340 FORMAT

Calibration Report: 13261A58

Sensor Model: CX-1050-AA-1.4L

Sensor Type: Cernox Resistor

Serial Number: X182092

Temperature Range: 1.40 K to 325 K

Name: CX-1050-AA-1.4L
Serial Number: X182092
Format: 4 ;Log Ohms/Kelvin
Limit: 325.0
Coefficient: 1 ;Negative

Point 1: 1.82624,325.000	Point 51: 2.29008, 91.500	Point 101: 2.90972, 14.750
Point 2: 1.83292,319.000	Point 52: 2.29982, 89.000	Point 102: 2.92268, 14.200
Point 3: 1.83918,313.500	Point 53: 2.30980, 86.500	Point 103: 2.93622, 13.650
Point 4: 1.84556,308.000	Point 54: 2.32005, 84.000	Point 104: 2.95038, 13.100
Point 5: 1.85207,302.500	Point 55: 2.33059, 81.500	Point 105: 2.96388, 12.600
Point 6: 1.85872,297.000	Point 56: 2.33926, 79.500	Point 106: 2.97800, 12.100
Point 7: 1.86552,291.500	Point 57: 2.34813, 77.500	Point 107: 2.99282, 11.600
Point 8: 1.87246,286.000	Point 58: 2.35722, 75.500	Point 108: 3.00841, 11.100
Point 9: 1.87956,280.500	Point 59: 2.36653, 73.500	Point 109: 3.02320, 10.650
Point 10: 1.88681,275.000	Point 60: 2.37608, 71.500	Point 110: 3.03873, 10.200
Point 11: 1.89423,269.500	Point 61: 2.38589, 69.500	Point 111: 3.05512, 9.750
Point 12: 1.90183,264.000	Point 62: 2.39597, 67.500	Point 112: 3.07247, 9.300
Point 13: 1.90960,258.500	Point 63: 2.40635, 65.500	Point 113: 3.08881, 8.900
Point 14: 1.91756,253.000	Point 64: 2.41703, 63.500	Point 114: 3.10606, 8.500
Point 15: 1.92571,247.500	Point 65: 2.42803, 61.500	Point 115: 3.12439, 8.100
Point 16: 1.93329,242.500	Point 66: 2.43997, 59.400	Point 116: 3.14390, 7.700
Point 17: 1.94104,237.500	Point 67: 2.45053, 57.600	Point 117: 3.16212, 7.350
Point 18: 1.94896,232.500	Point 68: 2.46141, 55.800	Point 118: 3.18146, 7.000
Point 19: 1.95707,227.500	Point 69: 2.47264, 54.000	Point 119: 3.20213, 6.650
Point 20: 1.96537,222.500	Point 70: 2.48424, 52.200	Point 120: 3.22430, 6.300
Point 21: 1.97386,217.500	Point 71: 2.49623, 50.400	Point 121: 3.24890, 5.940
Point 22: 1.98256,212.500	Point 72: 2.50865, 48.600	Point 122: 3.27252, 5.620
Point 23: 1.99146,207.500	Point 73: 2.52151, 46.800	Point 123: 3.29806, 5.300
Point 24: 2.00058,202.500	Point 74: 2.53337, 45.200	Point 124: 3.32404, 5.000
Point 25: 2.00993,197.500	Point 75: 2.54562, 43.600	Point 125: 3.35033, 4.720
Point 26: 2.01952,192.500	Point 76: 2.55833, 42.000	Point 126: 3.37886, 4.440
Point 27: 2.02935,187.500	Point 77: 2.57150, 40.400	Point 127: 3.40780, 4.180
Point 28: 2.03944,182.500	Point 78: 2.58432, 38.900	Point 128: 3.43442, 3.960
Point 29: 2.04980,177.500	Point 79: 2.59763, 37.400	Point 129: 3.45778, 3.780
Point 30: 2.05937,173.000	Point 80: 2.61146, 35.900	Point 130: 3.48137, 3.610
Point 31: 2.06916,168.500	Point 81: 2.62585, 34.400	Point 131: 3.50662, 3.440
Point 32: 2.07921,164.000	Point 82: 2.63986, 33.000	Point 132: 3.53378, 3.270
Point 33: 2.08951,159.500	Point 83: 2.65443, 31.600	Point 133: 3.56134, 3.110
Point 34: 2.10009,155.000	Point 84: 2.66964, 30.200	Point 134: 3.58917, 2.960
Point 35: 2.11095,150.500	Point 85: 2.68440, 28.900	Point 135: 3.61917, 2.810
Point 36: 2.12211,146.000	Point 86: 2.69980, 27.600	Point 136: 3.65172, 2.660
Point 37: 2.13360,141.500	Point 87: 2.71593, 26.300	Point 137: 3.68477, 2.520
Point 38: 2.14541,137.000	Point 88: 2.73153, 25.100	Point 138: 3.72072, 2.380
Point 39: 2.15623,133.000	Point 89: 2.74786, 23.900	Point 139: 3.75725, 2.250
Point 40: 2.16733,129.000	Point 90: 2.76503, 22.700	Point 140: 3.79714, 2.120
Point 41: 2.17875,125.000	Point 91: 2.78160, 21.600	Point 141: 3.84111, 1.990
Point 42: 2.19050,121.000	Point 92: 2.79901, 20.500	Point 142: 3.88596, 1.870
Point 43: 2.20262,117.000	Point 93: 2.81235, 19.700	Point 143: 3.93550, 1.750
Point 44: 2.21511,113.000	Point 94: 2.82355, 19.050	Point 144: 3.98603, 1.640
Point 45: 2.22801,109.000	Point 95: 2.83516, 18.400	Point 145: 4.04213, 1.530
Point 46: 2.24135,105.000	Point 96: 2.84720, 17.750	Point 146: 4.09945, 1.430
Point 47: 2.25342,101.500	Point 97: 2.85972, 17.100	Point 147: 4.11859, 1.400
Point 48: 2.26228, 99.000	Point 98: 2.87175, 16.500	
Point 49: 2.27132, 96.500	Point 99: 2.88424, 15.900	
Point 50: 2.28059, 94.000	Point 100: 2.89727, 15.300	

BREAKPOINTS 91C/93C/330 FORMAT

Calibration Report: 13261A58

Sensor Model: CX-1050-AA-1.4L

Sensor Type: Cernox Resistor

Serial Number: X182092

Temperature Range: 1.40 K to 325 K

Interpolation Method: Lagrangian

Limit: 325.0 (Kelvin)

Format: 4 (Log Ohms/Kelvin)

Number of Breakpoints: 53

No.	Units	Temperature (K)	No.	Units	Temperature (K)
1	1.82626	325.0	31	3.00214	11.3
2	1.82736	324.0	32	3.05707	9.7
3	1.84440	309.0	33	3.11062	8.4
4	1.86242	294.0	34	3.16488	7.3
5	1.88153	279.0	35	3.21791	6.4
6	1.90184	264.0	36	3.27421	5.6
7	1.92348	249.0	37	3.32421	5.0
8	1.94658	234.0	38	3.37273	4.5
9	1.97131	219.0	39	3.42956	4.0
10	1.99784	204.0	40	3.48294	3.6
11	2.02640	189.0	41	3.52900	3.3
12	2.05724	174.0	42	3.58171	3.0
13	2.09069	159.0	43	3.62145	2.8
14	2.12720	144.0	44	3.66576	2.6
15	2.16735	129.0	45	3.71564	2.4
16	2.21198	114.0	46	3.77242	2.2
17	2.26229	99.0	47	3.80394	2.1
18	2.32007	84.0	48	3.83792	2.0
19	2.38840	69.0	49	3.87467	1.9
20	2.43942	59.5	50	3.91461	1.8
21	2.49898	50.0	51	3.95823	1.7
22	2.53490	45.0	52	4.05915	1.5
23	2.57491	40.0	53	4.11849	1.4
24	2.62007	35.0			
25	2.67192	30.0			
26	2.72893	25.3			
27	2.78321	21.5			
28	2.83885	18.2			
29	2.89291	15.5			
30	2.94781	13.2			

Temperature for Resistance Decades:

Res. (Ohms)	Temp. (K)
100	202.825
1000	11.368
10000	1.612

BREAKPOINTS 234 FORMAT

Calibration Report: 13261A58

Sensor Model: CX-1050-AA-1.4L

Sensor Type: Cernox Resistor

Serial Number: X182092

Temperature Range: 1.40 K to 325 K

Maximum Temperature Error:

1.4 - 10 K:	0.009 K
10 - 20 K:	0.016 K
20 - 40 K:	0.010 K
40 - 100 K:	0.021 K
> 100 K:	0.081 K

BP #	Temp. (K)	Res. (W)	Log10 Res.	BP #	Temp. (K)	Res. (W)	Log10 Res.
1	312.791	69.18310	1.840	46	24.475	549.5409	2.740
2	295.964	72.44360	1.860	47	23.050	575.4399	2.760
3	280.169	75.85776	1.880	48	21.708	602.5596	2.780
4	265.323	79.43282	1.900	49	20.444	630.9573	2.800
5	251.347	83.17638	1.920	50	19.255	660.6934	2.820
6	238.171	87.09636	1.940	51	18.138	691.8310	2.840
7	225.730	91.20108	1.960	52	17.088	724.4360	2.860
8	213.966	95.49926	1.980	53	16.103	758.5776	2.880
9	202.826	100.0000	2.000	54	15.179	794.3282	2.900
10	192.263	104.7129	2.020	55	14.314	831.7638	2.920
11	182.238	109.6478	2.040	56	13.503	870.9636	2.940
12	172.713	114.8154	2.060	57	12.743	912.0108	2.960
13	163.659	120.2264	2.080	58	12.033	954.9926	2.980
14	155.046	125.8925	2.100	59	11.368	1000.000	3.000
15	146.852	131.8257	2.120	60	10.166	1096.478	3.040
16	139.055	138.0384	2.140	61	9.115	1202.264	3.080
17	131.636	144.5440	2.160	62	8.195	1318.257	3.120
18	124.577	151.3561	2.180	63	7.391	1445.440	3.160
19	117.863	158.4893	2.200	64	6.687	1584.893	3.200
20	111.478	165.9587	2.220	65	6.069	1737.801	3.240
21	105.409	173.7801	2.240	66	5.526	1905.461	3.280
22	99.641	181.9701	2.260	67	5.047	2089.296	3.320
23	94.161	190.5461	2.280	68	4.624	2290.868	3.360
24	88.958	199.5262	2.300	69	4.250	2511.886	3.400
25	84.018	208.9296	2.320	70	3.917	2754.229	3.440
26	79.333	218.7762	2.340	71	3.620	3019.952	3.480
27	74.900	229.0868	2.360	72	3.356	3311.311	3.520
28	70.698	239.8833	2.380	73	3.118	3630.781	3.560
29	66.720	251.1886	2.400	74	2.905	3981.072	3.600
30	62.957	263.0268	2.420	75	2.714	4365.158	3.640
31	59.399	275.4229	2.440	76	2.540	4786.301	3.680
32	56.035	288.4032	2.460	77	2.384	5248.075	3.720
33	52.856	301.9952	2.480	78	2.241	5754.399	3.760
34	49.851	316.2278	2.500	79	2.112	6309.573	3.800
35	47.013	331.1311	2.520	80	1.994	6918.310	3.840
36	44.331	346.7369	2.540	81	1.886	7585.776	3.880
37	41.797	363.0781	2.560	82	1.787	8317.638	3.920
38	39.404	380.1894	2.580	83	1.696	9120.108	3.960
39	37.143	398.1072	2.600	84	1.612	10000.00	4.000
40	35.007	416.8694	2.620	85	1.430	12589.25	4.100
41	32.990	436.5158	2.640	86	1.279	15848.93	4.200
42	31.085	457.0882	2.660				
43	29.286	478.6301	2.680				
44	27.588	501.1872	2.700				
45	25.986	524.8075	2.720				