Certificate of Calibration
Report Number: 784610

Sensor Model: CX-1050-CU-HT-1.4L	Serial Number: X93305
Sensor Type: Cernox Resistor	Sales Order: 91121-1
Sensor Excitation: see *Test Data* page of report	Date: May 16, 2014
Temperature Range: 1.40K to 325K	Due: May 16, 2015

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 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 9001:2008.

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.

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

Reported by: Todd Rittershausen
Calibration Engineer/Technician

Approved by: John Krause
Metrology

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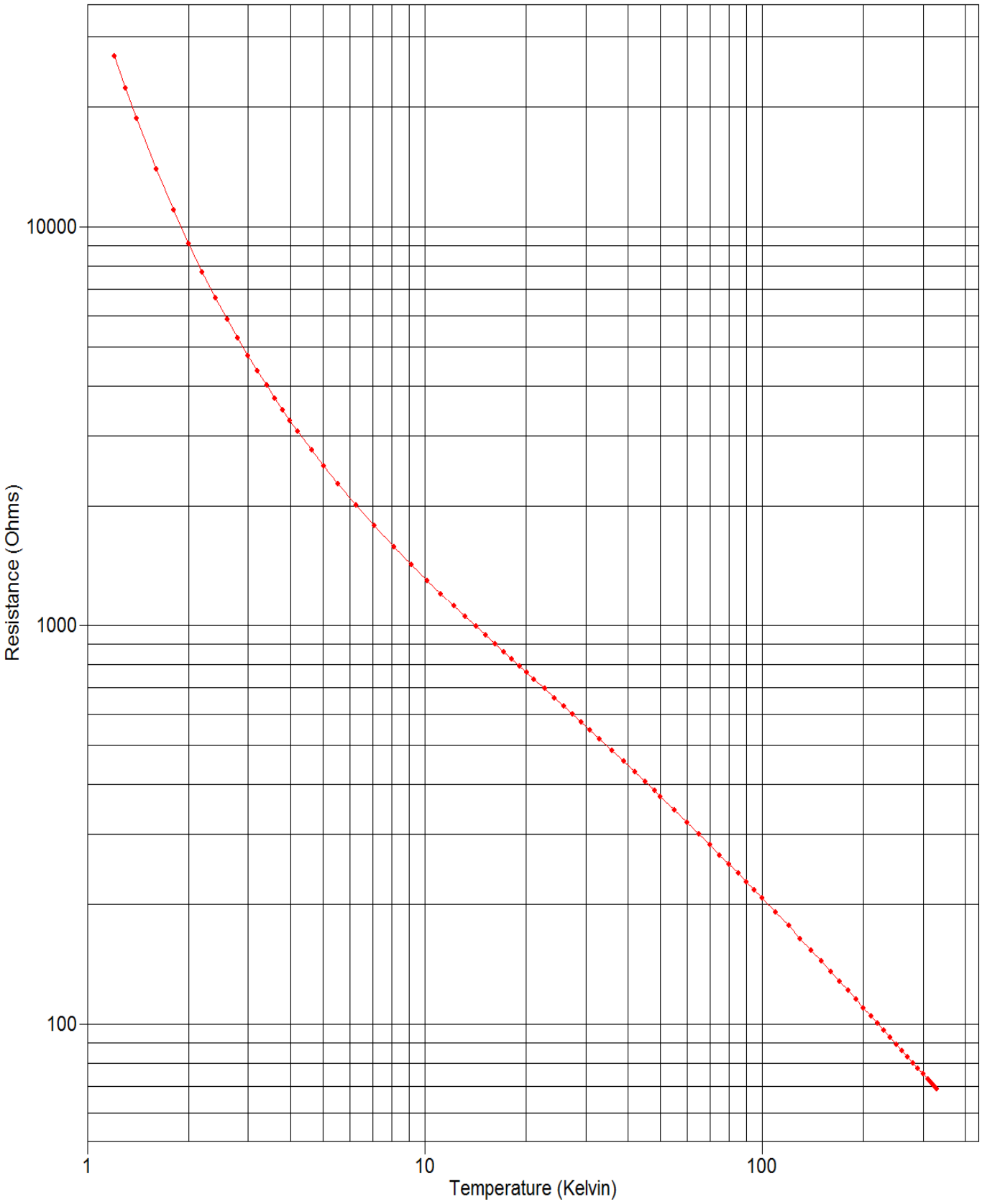
DATA PLOT

Calibration Report: 784610
Sensor Model: CX-1050-CU-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 91121-1
Serial Number: X93305
Temperature Range: 1.40K to 325K



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F010-04-00_B 06/21/2011

TEST DATA

Calibration Report: 784610
Sensor Model: CX-1050-CU-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 91121-1
Serial Number: X93305
Temperature Range: 1.40K to 325K

Index	Temp. (K)	Resistance (Ω)	Excitation	Index	Temp. (K)	Resistance (Ω)	Excitation
1	1.20552	26822.3	2mV±25%	46	41.9556	429.675	2mV±25%
2	1.30144	22217.8	2mV±25%	47	44.9629	406.345	2mV±25%
3	1.39984	18710.2	2mV±25%	48	47.9542	385.645	2mV±25%
4	1.60007	13992.6	2mV±25%	49	49.9530	373.005	2mV±25%
5	1.79971	11057.2	2mV±25%	50	54.9490	344.920	2mV±25%
6	2.00100	9072.47	2mV±25%	51	59.9522	320.925	2mV±25%
7	2.19641	7710.80	2mV±25%	52	64.9543	300.183	2mV±25%
8	2.40140	6656.42	2mV±25%	53	69.9552	282.049	2mV±25%
9	2.60072	5874.58	2mV±25%	54	74.9526	266.043	2mV±25%
10	2.79800	5265.01	2mV±25%	55	79.9504	251.823	2mV±25%
11	2.99678	4769.32	2mV±25%	56	84.9466	239.063	2mV±25%
12	3.20023	4354.06	2mV±25%	57	89.9449	227.558	2mV±25%
13	3.40068	4014.14	2mV±25%	58	94.9437	217.109	2mV±25%
14	3.59927	3729.22	2mV±25%	59	99.9441	207.595	2mV±25%
15	3.80070	3482.03	2mV±25%	60	109.946	190.853	2mV±25%
16	3.99506	3275.27	2mV±25%	61	119.950	176.584	2mV±25%
17	4.20106	3084.53	2mV±25%	62	129.942	164.295	2mV±25%
18	4.62723	2758.77	2mV±25%	63	139.951	153.568	2mV±25%
19	5.03427	2516.17	2mV±25%	64	149.957	144.133	2mV±25%
20	5.54349	2272.63	2mV±25%	65	159.964	135.769	2mV±25%
21	6.25982	2010.38	2mV±25%	66	169.969	128.305	2mV±25%
22	7.07637	1787.35	2mV±25%	67	179.971	121.620	2mV±25%
23	8.10387	1579.26	2mV±25%	68	189.973	115.591	2mV±25%
24	9.13280	1422.56	2mV±25%	69	199.976	110.126	2mV±25%
25	10.1607	1300.01	2mV±25%	70	209.989	105.154	2mV±25%
26	11.1836	1201.54	2mV±25%	71	219.997	100.618	2mV±25%
27	12.1965	1120.52	2mV±25%	72	230.002	96.4749	2mV±25%
28	13.1999	1052.49	2mV±25%	73	240.001	92.6649	2mV±25%
29	14.1925	994.487	2mV±25%	74	250.006	89.1578	2mV±25%
30	15.1799	943.988	2mV±25%	75	260.021	85.9162	2mV±25%
31	16.1620	899.594	2mV±25%	76	270.033	82.9056	2mV±25%
32	17.1342	860.231	2mV±25%	77	280.020	80.1354	2mV±25%
33	18.1089	824.636	2mV±25%	78	290.044	77.5406	2mV±25%
34	19.0819	792.433	2mV±25%	79	300.053	75.1293	2mV±25%
35	20.0553	762.929	2mV±25%	80	310.061	72.8750	2mV±25%
36	21.1263	733.325	2mV±25%	81	315.066	71.8040	2mV±25%
37	22.7109	694.020	2mV±25%	82	320.089	70.7672	2mV±25%
38	24.3072	658.911	2mV±25%	83	326.101	69.5681	2mV±25%
39	25.8870	627.841	2mV±25%	84	330.099	68.7941	2mV±25%
40	27.4810	599.618	2mV±25%				
41	29.0754	574.022	2mV±25%				
42	30.8756	547.790	2mV±25%				
43	32.9765	520.281	2mV±25%				
44	35.9647	485.877	2mV±25%				
45	38.9704	455.800	2mV±25%				

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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/NCSL 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 (± 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.

POLYNOMIAL EQUATION

Calibration Report: 784610 Sales Order: 91121-1
Sensor Model: CX-1050-CU-HT-1.4L Serial Number: X93305
Sensor Type: Cernox Resistor Temperature Range: 1.40K to 325K

Polynomial Type: Chebychev
Useful Range of Fit:

1.40 K	to	14.2 K
1.874e+4 Ohms	to	994.5 Ohms

Lower and Upper limits of Log(Resistance) used in computing Chebychev coefficients:
ZL = 2.95404664089 ZU = 4.42849542241

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	5.461116	1.8310E-04	29825.07
1	-6.300528	2.9627E-04	-21266.51
2	2.858246	2.6434E-04	10812.96
3	-1.087452	2.6841E-04	-4051.43
4	0.349620	2.5694E-04	1360.69
5	-0.091330	2.3588E-04	-387.18
6	0.016254	2.2769E-04	71.38
7	0.000052	2.4017E-04	0.22
8	-0.001463	2.4599E-04	-5.95
9	0.001141	2.3701E-04	4.81

Z = Log(Resistance)

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

Temp. (K) = ΣA_i* COS(i * ARCCOS(k)), where 0 <= i <= 9
and the A_i's are the coefficients in the table above.

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POLYNOMIAL EQUATION

Calibration Report: 784610
Sensor Model: CX-1050-CU-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 91121-1
Serial Number: X93305
Temperature Range: 1.40K to 325K

Polynomial Type: Chebychev
Temp. (K) vs. Log(Resistance)

	R Meas. (Ω)	T Meas. (K)	T Eq. (K)	T diff. (mK)
1	26822.26	1.20552	1.20565	-0.13
2	22217.85	1.30144	1.30074	0.69
3	18710.15	1.39984	1.40083	-0.99
4	13992.60	1.60007	1.59969	0.38
5	11057.25	1.79971	1.79899	0.72
6	9072.473	2.00100	2.00134	-0.33
7	7710.803	2.19641	2.19706	-0.65
8	6656.422	2.40140	2.40181	-0.41
9	5874.582	2.60072	2.60075	-0.04
10	5265.007	2.79800	2.79762	0.38
11	4769.316	2.99678	2.99635	0.43
12	4354.063	3.20023	3.19981	0.42
13	4014.139	3.40068	3.40019	0.50
14	3729.215	3.59927	3.59896	0.31
15	3482.030	3.80070	3.80063	0.06
16	3275.265	3.99506	3.99556	-0.49
17	3084.526	4.20106	4.20165	-0.59
18	2758.775	4.62723	4.62977	-2.54
19	2516.170	5.03427	5.03329	0.98
20	2272.630	5.54349	5.54220	1.29
21	2010.385	6.25982	6.25924	0.57
22	1787.353	7.07637	7.07631	0.06
23	1579.256	8.10387	8.10402	-0.15
24	1422.556	9.13280	9.13337	-0.56
25	1300.012	10.16072	10.16140	-0.68
26	1201.535	11.18357	11.18315	0.42
27	1120.519	12.19653	12.19614	0.39
28	1052.491	13.19990	13.19983	0.07
29	994.4870	14.19252	14.19230	0.22
30	943.9876	15.17986	15.18027	-0.41
31	899.5942	16.16197	16.16189	0.08

Order of Fit = 9 RMS error of fit = 0.70 mK
Largest absolute error = -2.54 mK at data point no. 18

POLYNOMIAL EQUATION

Calibration Report: 784610 Sales Order: 91121-1
Sensor Model: CX-1050-CU-HT-1.4L Serial Number: X93305
Sensor Type: Cernox Resistor Temperature Range: 1.40K to 325K

Polynomial Type: Chebychev
Useful Range of Fit:

14.2 K	to	79.9 K
994.5 Ohms	to	251.8 Ohms

Lower and Upper limits of Log(Resistance) used in computing Chebychev coefficients:
ZL = 2.35709142373 ZU = 3.0494191426

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	42.546947	3.2040E-04	132792.66
1	-37.806235	5.2125E-04	-72529.31
2	8.414280	4.7896E-04	17567.94
3	-1.062613	4.4520E-04	-2386.81
4	0.114209	4.2685E-04	267.56
5	-0.005482	4.0979E-04	-13.38
6	-0.005770	4.0770E-04	-14.15
7	-0.000193	3.9181E-04	-0.49
8	0.000798	3.9632E-04	2.01

Z = Log(Resistance)

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

Temp. (K) = ΣA_i* COS(i * ARCCOS(k)), where 0 <= i <= 8
and the A_i's are the coefficients in the table above.

POLYNOMIAL EQUATION

Calibration Report: 784610
Sensor Model: CX-1050-CU-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 91121-1
Serial Number: X93305
Temperature Range: 1.40K to 325K

Polynomial Type: Chebychev
Temp. (K) vs. Log(Resistance)

	R Meas. (Ω)	T Meas. (K)	T Eq. (K)	T diff. (mK)
27	1120.519	12.19614	12.19594	0.20
28	1052.491	13.19983	13.20008	-0.25
29	994.4870	14.19230	14.19270	-0.40
30	943.9876	15.17986	15.18028	-0.42
31	899.5942	16.16197	16.16098	0.99
32	860.2306	17.13423	17.13347	0.76
33	824.6363	18.10892	18.10891	0.01
34	792.4328	19.08188	19.08118	0.69
35	762.9285	20.05529	20.05666	-1.37
36	733.3253	21.12632	21.12719	-0.87
37	694.0195	22.71090	22.71108	-0.18
38	658.9111	24.30724	24.30752	-0.29
39	627.8414	25.88697	25.88745	-0.48
40	599.6179	27.48096	27.48015	0.81
41	574.0219	29.07535	29.07352	1.83
42	547.7896	30.87557	30.87514	0.43
43	520.2815	32.97648	32.97607	0.41
44	485.8770	35.96473	35.96503	-0.30
45	455.7999	38.97040	38.97497	-4.56
46	429.6754	41.95565	41.95493	0.72
47	406.3454	44.96290	44.96132	1.58
48	385.6451	47.95424	47.95261	1.64
49	373.0050	49.95296	49.95224	0.72
50	344.9196	54.94896	54.95075	-1.78
51	320.9247	59.95219	59.95285	-0.65
52	300.1827	64.95425	64.95340	0.85
53	282.0487	69.95518	69.95410	1.09
54	266.0428	74.95261	74.95537	-2.76
55	251.8228	79.95042	79.94838	2.04
56	239.0634	84.94657	84.94696	-0.39
57	227.5576	89.94490	89.94499	-0.08

Order of Fit = 8 RMS error of fit = 1.32 mK
Largest absolute error = -4.56 mK at data point no. 45

POLYNOMIAL EQUATION

Calibration Report: 784610 Sales Order: 91121-1
Sensor Model: CX-1050-CU-HT-1.4L Serial Number: X93305
Sensor Type: Cernox Resistor Temperature Range: 1.40K to 325K

Polynomial Type: Chebychev
Useful Range of Fit:

79.9 K	to	325. K
251.8 Ohms	to	69.78 Ohms

Lower and Upper limits of Log(Resistance) used in computing Chebychev coefficients:
ZL = 1.83755142483 ZU = 2.450324043

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	177.272380	1.3004E-03	136324.31
1	-126.992464	2.0087E-03	-63221.84
2	22.203075	1.9289E-03	11510.45
3	-2.975633	1.8330E-03	-1623.38
4	0.538760	1.7455E-03	308.65
5	-0.101454	1.7490E-03	-58.01
6	0.011082	1.7283E-03	6.41
7	-0.002944	1.6689E-03	-1.76

Z = Log(Resistance)

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

Temp. (K) = ΣA_i* COS(i * ARCCOS(k)), where 0 <= i <= 7
and the A_i's are the coefficients in the table above.

POLYNOMIAL EQUATION

Calibration Report: 784610
Sensor Model: CX-1050-CU-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 91121-1
Serial Number: X93305
Temperature Range: 1.40K to 325K

Polynomial Type: Chebychev
Temp. (K) vs. Log(Resistance)

	R Meas. (Ω)	T Meas. (K)	T Eq. (K)	T diff. (mK)
53	282.0487	69.95410	69.95280	1.29
54	266.0428	74.95537	74.95738	-2.02
55	251.8228	79.94838	79.94954	-1.15
56	239.0634	84.94657	84.94645	0.12
57	227.5576	89.94490	89.94251	2.39
58	217.1093	94.94370	94.94481	-1.11
59	207.5949	99.94411	99.94157	2.54
60	190.8535	109.94554	109.94380	1.74
61	176.5844	119.94990	119.95369	-3.80
62	164.2947	129.94192	129.94688	-4.96
63	153.5680	139.95064	139.95032	0.32
64	144.1330	149.95713	149.95357	3.57
65	135.7686	159.96423	159.96057	3.66
66	128.3050	169.96869	169.97187	-3.18
67	121.6198	179.97096	179.96835	2.61
68	115.5908	189.97263	189.96768	4.94
69	110.1257	199.97634	199.97720	-0.86
70	105.1542	209.98858	209.99262	-4.04
71	100.6181	219.99725	220.00779	-10.54
72	96.47493	230.00216	229.99908	3.08
73	92.66486	240.00107	240.00300	-1.94
74	89.15777	250.00639	250.00118	5.21
75	85.91622	260.02071	260.00868	12.03
76	82.90560	270.03346	270.05103	-17.58
77	80.13545	280.01967	280.00982	9.85
78	77.54061	290.04389	290.04152	2.37
79	75.12933	300.05268	300.04751	5.17
80	72.87504	310.06053	310.06836	-7.84
81	71.80398	315.06612	315.07664	-10.53
82	70.76716	320.08853	320.08769	0.85
83	69.56806	326.10057	326.09429	6.28
84	68.79414	330.09930	330.09779	1.51

Order of Fit = 7 RMS error of fit = 5.85 mK
Largest absolute error = -17.58 mK at data point no. 76

INTERPOLATION TABLE

Calibration Report: 784610 Sales Order: 91121-1
Sensor Model: CX-1050-CU-HT-1.4L Serial Number: X93305
Sensor Type: Cernox Resistor Temperature Range: 1.40K to 325K

Temp (K)	Res. (Ω)	dR/dT (Ω/K)	dlogR/dlogT	Temp (K)	Res. (Ω)	dR/dT (Ω/K)	dlogR/dlogT
1.400	18735.4	-30322.	-2.2658	15.50	928.939	-46.158	-0.77017
1.500	16063.7	-23454.	-2.1901	16.00	906.534	-43.509	-0.76792
1.600	13987.0	-18325.	-2.0962	16.50	885.388	-41.110	-0.76612
1.700	12354.1	-14536.	-2.0002	17.00	865.389	-38.922	-0.76460
1.800	11045.3	-11786.	-1.9207	17.50	846.434	-36.924	-0.76339
1.900	9973.95	-9731.8	-1.8539	18.00	828.437	-35.091	-0.76244
2.000	9083.35	-8148.3	-1.7941	18.50	811.319	-33.407	-0.76175
2.100	8332.88	-6908.2	-1.7410	19.00	795.009	-31.854	-0.76127
2.200	7693.34	-5919.8	-1.6928	19.50	779.445	-30.419	-0.76101
2.300	7142.66	-5120.5	-1.6488	20.00	764.573	-29.089	-0.76092
2.400	6664.48	-4464.7	-1.6078	21.00	736.704	-26.705	-0.76124
2.500	6245.97	-3921.6	-1.5697	22.00	711.059	-24.631	-0.76208
2.600	5877.20	-3467.3	-1.5339	23.00	687.356	-22.813	-0.76337
2.700	5550.15	-3084.2	-1.5004	24.00	665.362	-21.207	-0.76495
2.800	5258.44	-2758.7	-1.4689	25.00	644.882	-19.781	-0.76683
2.900	4996.85	-2480.1	-1.4394	26.00	625.751	-18.505	-0.76888
3.000	4761.12	-2240.3	-1.4116	27.00	607.829	-17.358	-0.77106
3.100	4547.72	-2032.6	-1.3855	28.00	590.997	-16.323	-0.77336
3.200	4353.71	-1851.7	-1.3610	29.00	575.150	-15.384	-0.77570
3.300	4176.63	-1693.3	-1.3379	30.00	560.200	-14.529	-0.77808
3.400	4014.43	-1553.9	-1.3160	31.00	546.067	-13.748	-0.78047
3.500	3865.32	-1430.6	-1.2954	32.00	532.683	-13.031	-0.78284
3.600	3727.84	-1321.3	-1.2759	33.00	519.985	-12.372	-0.78520
3.700	3600.68	-1223.7	-1.2575	34.00	507.921	-11.765	-0.78752
3.800	3482.75	-1136.5	-1.2400	35.00	496.441	-11.202	-0.78974
3.900	3373.09	-1058.1	-1.2234	36.00	485.503	-10.681	-0.79197
4.000	3270.87	-987.45	-1.2076	37.00	475.067	-10.197	-0.79415
4.200	3085.95	-865.74	-1.1783	38.00	465.099	-9.7454	-0.79623
4.400	2923.18	-764.96	-1.1514	39.00	455.566	-9.3249	-0.79829
4.600	2778.87	-680.65	-1.1267	40.00	446.440	-8.9320	-0.80028
4.800	2650.03	-609.70	-1.1043	42.00	429.305	-8.2189	-0.80408
5.000	2534.30	-549.17	-1.0835	44.00	413.508	-7.5903	-0.80766
5.200	2429.78	-497.30	-1.0643	46.00	398.896	-7.0333	-0.81106
5.400	2334.92	-452.38	-1.0462	48.00	385.335	-6.5367	-0.81426
5.600	2248.42	-413.49	-1.0298	50.00	372.714	-6.0928	-0.81735
5.800	2169.21	-379.34	-1.0143	52.00	360.934	-5.6935	-0.82026
6.000	2096.42	-349.22	-0.99947	54.00	349.914	-5.3331	-0.82302
6.500	1937.77	-288.39	-0.96736	56.00	339.579	-5.0076	-0.82580
7.000	1805.61	-242.32	-0.93943	58.00	329.864	-4.7114	-0.82841
7.500	1693.68	-206.81	-0.91581	60.00	320.715	-4.4419	-0.83100
8.000	1597.58	-178.69	-0.89479	65.00	300.003	-3.8640	-0.83720
8.500	1514.03	-156.25	-0.87721	70.00	281.893	-3.3958	-0.84324
9.000	1440.65	-137.88	-0.86134	75.00	265.908	-3.0097	-0.84888
9.500	1375.61	-122.77	-0.84782	77.35	259.024	-2.8514	-0.85147
10.00	1317.49	-110.09	-0.83563	80.00	251.687	-2.6891	-0.85473
10.50	1265.18	-99.432	-0.82521	85.00	238.934	-2.4190	-0.86056
11.00	1217.80	-90.314	-0.81577	90.00	227.432	-2.1880	-0.86582
11.50	1174.64	-82.498	-0.80767	95.00	216.999	-1.9899	-0.87114
12.00	1135.13	-75.713	-0.80040	100.0	207.489	-1.8185	-0.87645
12.50	1098.78	-69.809	-0.79416	105.0	198.778	-1.6691	-0.88167
13.00	1065.21	-64.597	-0.78835	110.0	190.767	-1.5380	-0.88684
13.50	1034.08	-59.994	-0.78322	115.0	183.372	-1.4222	-0.89194
14.00	1005.12	-55.928	-0.77899	120.0	176.523	-1.3193	-0.89687
14.50	978.077	-52.328	-0.77577	125.0	170.161	-1.2274	-0.90163
15.00	952.738	-49.085	-0.77280	130.0	164.234	-1.1448	-0.90620

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INTERPOLATION TABLE

Calibration Report: 784610
Sensor Model: CX-1050-CU-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 91121-1
Serial Number: X93305
Temperature Range: 1.40K to 325K

Temp (K)	Res. (Ω)	dR/dT (Ω/K)	dlogR/dlogT	Temp (K)	Res. (Ω)	dR/dT (Ω/K)	dlogR/dlogT
135.0	158.699	-1.0704	-0.91056	235.0	94.5304	-0.38071	-0.94642
140.0	153.518	-1.0030	-0.91467	240.0	92.6660	-0.36524	-0.94596
145.0	148.659	-0.94173	-0.91855	245.0	90.8766	-0.35065	-0.94533
150.0	144.092	-0.88585	-0.92217	250.0	89.1582	-0.33685	-0.94454
155.0	139.792	-0.83473	-0.92554	255.0	87.5068	-0.32381	-0.94360
160.0	135.738	-0.78783	-0.92865	260.0	85.9189	-0.31146	-0.94251
165.0	131.908	-0.74468	-0.93150	265.0	84.3911	-0.29976	-0.94129
170.0	128.285	-0.70488	-0.93409	270.0	82.9203	-0.28866	-0.93993
175.0	124.854	-0.66809	-0.93642	273.15	82.0216	-0.28197	-0.93902
180.0	121.600	-0.63401	-0.93850	275.0	81.5035	-0.27814	-0.93846
185.0	118.510	-0.60238	-0.94034	280.0	80.1381	-0.26814	-0.93686
190.0	115.572	-0.57295	-0.94193	285.0	78.8214	-0.25863	-0.93516
195.0	112.777	-0.54554	-0.94329	290.0	77.5510	-0.24959	-0.93335
200.0	110.114	-0.51996	-0.94441	295.0	76.3247	-0.24099	-0.93144
205.0	107.574	-0.49606	-0.94532	300.0	75.1404	-0.23280	-0.92945
210.0	105.151	-0.47368	-0.94600	305.0	73.9961	-0.22499	-0.92736
215.0	102.835	-0.45270	-0.94648	310.0	72.8899	-0.21754	-0.92520
220.0	100.622	-0.43301	-0.94675	315.0	71.8201	-0.21044	-0.92296
225.0	98.5032	-0.41451	-0.94683	320.0	70.7850	-0.20365	-0.92066
230.0	96.4746	-0.39710	-0.94671	325.0	69.7831	-0.19717	-0.91829

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THERMAL CYCLE TESTING

Sensor Model: CX-1050-CU-HT-1.4L Serial Number: X93305
Sensor Type: Cernox Resistor

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:	73.0 Ω
Liquid Nitrogen:	259 Ω
Liquid Helium:	3082 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 LSCI, 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 340 FORMAT

Calibration Report: 784610 Sales Order: 91121-1
Sensor Model: CX-1050-CU-HT-1.4L Serial Number: X93305
Sensor Type: Cernox Resistor Temperature Range: 1.40K to 325K

Name: CX-1050-CU-HT-1.4L
Serial number: X93305
Format: 4 ;Log Ohms/Kelvin
Limit: 325.0
Coefficient: 1 ;Negative

Point 1: 1.84373,325.000
Point 2: 1.85118,319.000
Point 3: 1.85815,313.500
Point 4: 1.86526,308.000
Point 5: 1.87251,302.500

Point 6: 1.87992,297.000
Point 7: 1.88748,291.500
Point 8: 1.89521,286.000
Point 9: 1.90310,280.500
Point 10: 1.91116,275.000

Point 11: 1.91940,269.500
Point 12: 1.92783,264.000
Point 13: 1.93644,258.500
Point 14: 1.94525,253.000
Point 15: 1.95427,247.500

Point 16: 1.96349,242.000
Point 17: 1.97294,236.500
Point 18: 1.98261,231.000
Point 19: 1.99161,226.000
Point 20: 2.00081,221.000

Point 21: 2.01022,216.000
Point 22: 2.01984,211.000
Point 23: 2.02969,206.000
Point 24: 2.03978,201.000
Point 25: 2.05011,196.000

Point 26: 2.06069,191.000
Point 27: 2.07153,186.000
Point 28: 2.08265,181.000
Point 29: 2.09406,176.000
Point 30: 2.10577,171.000

Point 31: 2.11659,166.500
Point 32: 2.12767,162.000
Point 33: 2.13903,157.500
Point 34: 2.15068,153.000
Point 35: 2.16264,148.500

Point 36: 2.17492,144.000
Point 37: 2.18755,139.500
Point 38: 2.20055,135.000
Point 39: 2.21392,130.500
Point 40: 2.22616,126.500

Point 41: 2.23873,122.500
Point 42: 2.25167,118.500
Point 43: 2.26499,114.500
Point 44: 2.27872,110.500
Point 45: 2.29290,106.500

Point 46: 2.30754,102.500
Point 47: 2.31889, 99.500
Point 48: 2.32855, 97.000
Point 49: 2.33844, 94.500
Point 50: 2.34856, 92.000

Point 51: 2.35893, 89.500
Point 52: 2.36956, 87.000
Point 53: 2.38046, 84.500
Point 54: 2.39166, 82.000
Point 55: 2.40317, 79.500

Point 56: 2.41499, 77.000
Point 57: 2.42717, 74.500
Point 58: 2.43720, 72.500
Point 59: 2.44746, 70.500
Point 60: 2.45799, 68.500

Point 61: 2.46880, 66.500
Point 62: 2.47991, 64.500
Point 63: 2.49134, 62.500
Point 64: 2.50310, 60.500
Point 65: 2.51460, 58.600

Point 66: 2.52709, 56.600
Point 67: 2.53998, 54.600
Point 68: 2.55196, 52.800
Point 69: 2.56431, 51.000
Point 70: 2.57707, 49.200

Point 71: 2.59025, 47.400
Point 72: 2.60390, 45.600
Point 73: 2.61804, 43.800
Point 74: 2.63108, 42.200
Point 75: 2.64455, 40.600

Point 76: 2.65851, 39.000
Point 77: 2.67300, 37.400
Point 78: 2.68806, 35.800
Point 79: 2.70275, 34.300
Point 80: 2.71801, 32.800

Point 81: 2.73393, 31.300
Point 82: 2.74942, 29.900
Point 83: 2.76558, 28.500
Point 84: 2.78248, 27.100
Point 85: 2.79892, 25.800

Point 86: 2.81614, 24.500
Point 87: 2.83283, 23.300
Point 88: 2.85033, 22.100
Point 89: 2.86879, 20.900
Point 90: 2.88175, 20.100

Point 91: 2.89260, 19.450
Point 92: 2.90384, 18.800
Point 93: 2.91548, 18.150
Point 94: 2.92756, 17.500
Point 95: 2.93914, 16.900

Point 96: 2.95116, 16.300
Point 97: 2.96366, 15.700
Point 98: 2.97670, 15.100
Point 99: 2.98918, 14.550
Point 100: 3.00218, 14.000

Point 101: 3.01577, 13.450
Point 102: 3.02871, 12.950
Point 103: 3.04224, 12.450
Point 104: 3.05645, 11.950
Point 105: 3.07137, 11.450

Point 106: 3.08553, 11.000
Point 107: 3.10039, 10.550
Point 108: 3.11608, 10.100
Point 109: 3.13266, 9.650
Point 110: 3.14829, 9.250

Point 111: 3.16479, 8.850
Point 112: 3.18230, 8.450
Point 113: 3.20095, 8.050
Point 114: 3.21835, 7.700
Point 115: 3.23681, 7.350

Point 116: 3.25653, 7.000
Point 117: 3.27765, 6.650
Point 118: 3.30039, 6.300
Point 119: 3.32572, 5.940
Point 120: 3.34857, 5.640

Point 121: 3.37320, 5.340
Point 122: 3.39993, 5.040
Point 123: 3.42710, 4.760
Point 124: 3.45667, 4.480
Point 125: 3.48676, 4.220

Point 126: 3.51194, 4.020
Point 127: 3.53479, 3.850
Point 128: 3.55921, 3.680
Point 129: 3.58543, 3.510
Point 130: 3.61198, 3.350

Point 131: 3.64053, 3.190
Point 132: 3.66945, 3.040
Point 133: 3.70065, 2.890
Point 134: 3.73453, 2.740
Point 135: 3.76895, 2.600

Point 136: 3.80638, 2.460
Point 137: 3.84737, 2.320
Point 138: 3.88918, 2.190
Point 139: 3.93143, 2.070
Point 140: 3.97776, 1.950

Point 141: 4.02903, 1.830
Point 142: 4.08129, 1.720
Point 143: 4.13404, 1.620
Point 144: 4.19279, 1.520
Point 145: 4.26499, 1.410

Point 146: 4.27266, 1.400

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BREAKPOINTS 91C/93C/330 FORMAT

Calibration Report: 784610 Sales Order: 91121-1
Sensor Model: CX-1050-CU-HT-1.4L Serial Number: X93305
Sensor Type: Cernox Resistor Temperature Range: 1.40K to 325K

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	1.84375	325.0	31	3.09876	10.6
2	1.84498	324.0	32	3.15443	9.1
3	1.86397	309.0	33	3.21334	7.8
4	1.88404	294.0	34	3.26852	6.8
5	1.90529	279.0	35	3.32148	6.0
6	1.92784	264.0	36	3.37680	5.3
7	1.95181	249.0	37	3.43340	4.7
8	1.97732	234.0	38	3.48939	4.2
9	2.00456	219.0	39	3.54192	3.8
10	2.03372	204.0	40	3.60362	3.4
11	2.06501	189.0	41	3.65779	3.1
12	2.09873	174.0	42	3.69870	2.9
13	2.13523	159.0	43	3.74430	2.7
14	2.17495	144.0	44	3.79560	2.5
15	2.21850	129.0	45	3.85386	2.3
16	2.26671	114.0	46	3.88612	2.2
17	2.32082	99.0	47	3.92080	2.1
18	2.38270	84.0	48	3.95825	2.0
19	2.45535	69.0	49	3.99887	1.9
20	2.50914	59.5	50	4.04318	1.8
21	2.57138	50.0	51	4.09181	1.7
22	2.60859	45.0	52	4.20585	1.5
23	2.64976	40.0	53	4.27266	1.4
24	2.69587	35.0			
25	2.74834	30.0			
26	2.80948	25.0			
27	2.86729	21.0			
28	2.92570	17.6			
29	2.98348	14.8			
30	3.04091	12.5			

Temperature for Resistance Decades:

Res. (Ohms)	Temp. (K)
100	221.442
1000	14.090
10000	1.897

BREAKPOINTS 234 FORMAT

Calibration Report: 784610 Sales Order: 91121-1
Sensor Model: CX-1050-CU-HT-1.4L Serial Number: X93305
Sensor Type: Cernox Resistor Temperature Range: 1.40K to 325K

Maximum Temperature Error:

1.4 - 10K:	0.013K
10 - 20K:	0.021K
20 - 40K:	0.009K
40 - 100K:	0.018K
> 100K:	0.063K

BP #	Temp. (K)	Res. (Ω)	Log10 Res.	BP #	Temp. (K)	Res. (Ω)	Log10 Res.
1	312.064	72.44360	1.860	46	28.981	575.4399	2.760
2	296.951	75.85776	1.880	47	27.306	602.5596	2.780
3	282.659	79.43282	1.900	48	25.721	630.9573	2.800
4	269.114	83.17638	1.920	49	24.222	660.6934	2.820
5	256.279	87.09636	1.940	50	22.805	691.8310	2.840
6	244.075	91.20108	1.960	51	21.468	724.4360	2.860
7	232.483	95.49926	1.980	52	20.208	758.5776	2.880
8	221.444	100.0000	2.000	53	19.021	794.3282	2.900
9	210.928	104.7129	2.020	54	17.905	831.7638	2.920
10	200.900	109.6478	2.040	55	16.858	870.9636	2.940
11	191.330	114.8154	2.060	56	15.875	912.0108	2.960
12	182.191	120.2264	2.080	57	14.954	954.9926	2.980
13	173.457	125.8925	2.100	58	14.092	1000.000	3.000
14	165.110	131.8257	2.120	59	12.533	1096.478	3.040
15	157.128	138.0384	2.140	60	11.175	1202.264	3.080
16	149.491	144.5440	2.160	61	9.993	1318.257	3.120
17	142.186	151.3561	2.180	62	8.965	1445.440	3.160
18	135.196	158.4893	2.200	63	8.072	1584.893	3.200
19	128.508	165.9587	2.220	64	7.293	1737.801	3.240
20	122.111	173.7801	2.240	65	6.614	1905.461	3.280
21	115.993	181.9701	2.260	66	6.020	2089.296	3.320
22	110.144	190.5461	2.280	67	5.500	2290.868	3.360
23	104.555	199.5262	2.300	68	5.041	2511.886	3.400
24	99.213	208.9296	2.320	69	4.637	2754.229	3.440
25	94.114	218.7762	2.340	70	4.278	3019.952	3.480
26	89.249	229.0868	2.360	71	3.960	3311.311	3.520
27	84.609	239.8833	2.380	72	3.676	3630.781	3.560
28	80.186	251.1886	2.400	73	3.422	3981.072	3.600
29	75.968	263.0268	2.420	74	3.194	4365.158	3.640
30	71.951	275.4229	2.440	75	2.989	4786.301	3.680
31	68.128	288.4032	2.460	76	2.804	5248.075	3.720
32	64.488	301.9952	2.480	77	2.636	5754.399	3.760
33	61.025	316.2278	2.500	78	2.484	6309.573	3.800
34	57.732	331.1311	2.520	79	2.345	6918.310	3.840
35	54.601	346.7369	2.540	80	2.218	7585.776	3.880
36	51.626	363.0781	2.560	81	2.102	8317.638	3.920
37	48.799	380.1894	2.580	82	1.996	9120.108	3.960
38	46.112	398.1072	2.600	83	1.897	10000.00	4.000
39	43.561	416.8694	2.620	84	1.684	12589.25	4.100
40	41.138	436.5158	2.640	85	1.509	15848.93	4.200
41	38.837	457.0882	2.660	86	1.362	19952.62	4.300
42	36.653	478.6301	2.680	87	1.238	25118.86	4.400
43	34.581	501.1872	2.700				
44	32.614	524.8075	2.720				
45	30.749	549.5409	2.740				

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