CALIBRATION CERTIFICATE
Report Number: 939801

Sensor Model: CX-1050-SD-HT-1.4L	Serial Number: X117656
Sensor Type: Cernox Resistor	Sales Order: 113048
Sensor Excitation: see *Test Data* page of report	Date: November 28, 2016
Temperature Range: 1.40 K to 325 K	Due: November 28, 2017

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: Derick Gillette
Calibration Engineer/Technician

Approved by: John Krause
Metrology

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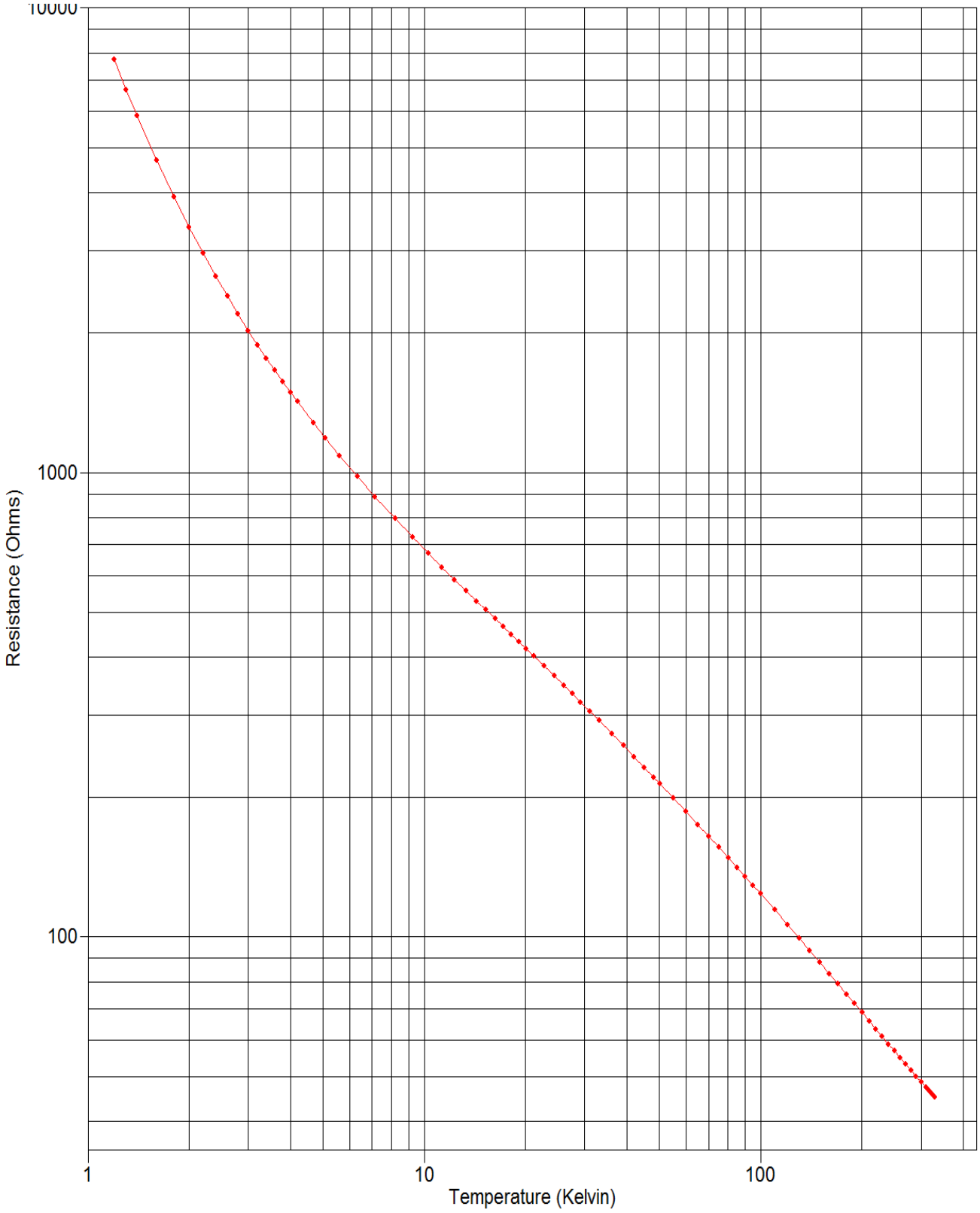
DATA PLOT

Calibration Report: 939801
Sensor Model: CX-1050-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 113048
Serial Number: X117656
Temperature Range: 1.40 K to 325 K



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TEST DATA

Calibration Report: 939801
Sensor Model: CX-1050-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 113048
Serial Number: X117656
Temperature Range: 1.40 K to 325 K

Index	Temp. (K)	Resistance (Ω)	Excitation	Index	Temp. (K)	Resistance (Ω)	Excitation
1	1.20000	7757.51	2mV±25%	46	42.1306	243.877	2mV±25%
2	1.30156	6675.13	2mV±25%	47	45.1399	231.498	2mV±25%
3	1.40074	5866.30	2mV±25%	48	48.1370	220.445	2mV±25%
4	1.60020	4702.39	2mV±25%	49	50.1328	213.707	2mV±25%
5	1.80058	3921.44	2mV±25%	50	55.1268	198.655	2mV±25%
6	2.00096	3369.42	2mV±25%	51	60.1235	185.716	2mV±25%
7	2.20007	2961.66	2mV±25%	52	65.1226	174.472	2mV±25%
8	2.40011	2645.19	2mV±25%	53	70.1272	164.597	2mV±25%
9	2.59845	2396.52	2mV±25%	54	75.1270	155.863	2mV±25%
10	2.79949	2191.87	2mV±25%	55	80.1236	148.056	2mV±25%
11	3.00133	2022.60	2mV±25%	56	85.1188	141.035	2mV±25%
12	3.20032	1882.70	2mV±25%	57	90.1171	134.684	2mV±25%
13	3.39923	1763.39	2mV±25%	58	95.1121	128.914	2mV±25%
14	3.59892	1660.28	2mV±25%	59	100.109	123.624	2mV±25%
15	3.79902	1570.13	2mV±25%	60	110.112	114.291	2mV±25%
16	3.99894	1491.09	2mV±25%	61	120.118	106.308	2mV±25%
17	4.19855	1420.97	2mV±25%	62	130.112	99.4033	2mV±25%
18	4.68117	1281.24	2mV±25%	63	140.123	93.3492	2mV±25%
19	5.09116	1186.03	2mV±25%	64	150.126	88.0240	2mV±25%
20	5.60611	1088.41	2mV±25%	65	160.130	83.2882	2mV±25%
21	6.32673	981.605	2mV±25%	66	170.135	79.0546	2mV±25%
22	7.15094	887.661	2mV±25%	67	180.139	75.2529	2mV±25%
23	8.19223	796.991	2mV±25%	68	190.143	71.8229	2mV±25%
24	9.23398	727.222	2mV±25%	69	200.150	68.7078	2mV±25%
25	10.2705	671.779	2mV±25%	70	210.148	65.8806	2mV±25%
26	11.3019	626.307	2mV±25%	71	220.146	63.2924	2mV±25%
27	12.3154	588.711	2mV±25%	72	230.160	60.9216	2mV±25%
28	13.3114	556.940	2mV±25%	73	240.169	58.7451	2mV±25%
29	14.2960	529.497	2mV±25%	74	250.166	56.7402	2mV±25%
30	15.2715	505.459	2mV±25%	75	260.159	54.8948	2mV±25%
31	16.2403	484.076	2mV±25%	76	270.174	53.1735	2mV±25%
32	17.2051	464.915	2mV±25%	77	280.179	51.5820	2mV±25%
33	18.1637	447.600	2mV±25%	78	290.175	50.1074	2mV±25%
34	19.1256	431.729	2mV±25%	79	300.195	48.7227	2mV±25%
35	20.0916	417.053	2mV±25%	80	310.190	47.4389	2mV±25%
36	21.1554	402.208	2mV±25%	81	315.199	46.8284	2mV±25%
37	22.7294	382.353	2mV±25%	82	320.203	46.2354	2mV±25%
38	24.3486	364.154	2mV±25%	83	326.235	45.5501	2mV±25%
39	25.9700	347.808	2mV±25%	84	330.216	45.1101	2mV±25%
40	27.5888	333.054	2mV±25%				
41	29.2049	319.646	2mV±25%				
42	31.0134	306.023	2mV±25%				
43	33.1218	291.632	2mV±25%				
44	36.1284	273.541	2mV±25%				
45	39.1341	257.761	2mV±25%				

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Calibration Report: 939801 Sales Order: 113048
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X117656
Sensor Type: Cernox Resistor 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/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.

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POLYNOMIAL EQUATION

Calibration Report: 939801 Sales Order: 113048
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X117656
Sensor Type: Cernox Resistor Temperature Range: 1.40 K to 325 K

Polynomial Type: Chebychev
Useful Range of Fit:

1.40 K	to	14.3 K
5871 ohms	to	529.5 ohms

Lower and Upper limits of Log(Resistance) used in computing Chebychev coefficients:
ZL = 2.68491328511 ZU = 3.88972245339

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	5.649284	1.0244E-04	55148.16
1	-6.496949	1.6643E-04	-39036.24
2	2.795808	1.4771E-04	18927.62
3	-0.969290	1.5013E-04	-6456.15
4	0.271303	1.4333E-04	1892.90
5	-0.056705	1.3263E-04	-427.54
6	0.005340	1.2709E-04	42.02
7	0.002012	1.3293E-04	15.14
8	-0.001516	1.3589E-04	-11.16
9	0.000707	1.3339E-04	5.30

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: 939801
Sensor Model: CX-1050-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 113048
Serial Number: X117656
Temperature Range: 1.40 K to 325 K

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

	R Meas. (W)	T Meas. (K)	T Eq. (K)	T diff. (mK)
1	7757.512	1.20000	1.19999	0.01
2	6675.130	1.30156	1.30160	-0.04
3	5866.299	1.40074	1.40071	0.03
4	4702.395	1.60020	1.60012	0.08
5	3921.441	1.80058	1.80073	-0.16
6	3369.420	2.00096	2.00101	-0.05
7	2961.659	2.20007	2.19990	0.17
8	2645.194	2.40011	2.40006	0.05
9	2396.522	2.59845	2.59836	0.09
10	2191.869	2.79949	2.79965	-0.16
11	2022.604	3.00133	3.00148	-0.15
12	1882.701	3.20032	3.20025	0.07
13	1763.395	3.39923	3.39920	0.02
14	1660.275	3.59892	3.59871	0.21
15	1570.132	3.79902	3.79904	-0.03
16	1491.089	3.99894	3.99900	-0.06
17	1420.965	4.19855	4.19928	-0.73
18	1281.241	4.68117	4.68030	0.87
19	1186.032	5.09116	5.09056	0.60
20	1088.411	5.60611	5.60721	-1.10
21	981.6047	6.32673	6.32682	-0.09
22	887.6606	7.15094	7.15019	0.75
23	796.9909	8.19223	8.19277	-0.53
24	727.2218	9.23398	9.23426	-0.27
25	671.7790	10.27046	10.26973	0.73
26	626.3074	11.30185	11.30210	-0.25
27	588.7109	12.31536	12.31536	-0.01
28	556.9396	13.31136	13.31142	-0.06
29	529.4970	14.29598	14.29626	-0.28
30	505.4585	15.27147	15.27106	0.41
31	484.0757	16.24031	16.24044	-0.14

Order of Fit = 9 RMS error of fit = 0.39 mK
Largest absolute error = -1.10 mK at data point no. 20

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POLYNOMIAL EQUATION

Calibration Report: 939801 Sales Order: 113048
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X117656
Sensor Type: Cernox Resistor Temperature Range: 1.40 K to 325 K

Polynomial Type: Chebychev
Useful Range of Fit:

14.3 K	to	80.1 K
529.5 ohms	to	148.1 ohms

Lower and Upper limits of Log(Resistance) used in computing Chebychev coefficients:
ZL = 2.12931576936 ZU = 2.76990209894

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	42.861108	2.8046E-04	152825.72
1	-37.853036	4.5676E-04	-82873.62
2	8.243253	4.1815E-04	19713.72
3	-1.043856	3.9333E-04	-2653.91
4	0.116862	3.7595E-04	310.84
5	-0.003632	3.5384E-04	-10.26
6	-0.005492	3.5538E-04	-15.46

Z = Log(Resistance)

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

Temp. (K) = ΣA_i* COS(i * ARCCOS(k)), where 0 <= i <= 6
and the A_i's are the coefficients in the table above.

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POLYNOMIAL EQUATION

Calibration Report: 939801
Sensor Model: CX-1050-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 113048
Serial Number: X117656
Temperature Range: 1.40 K to 325 K

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

	R Meas. (W)	T Meas. (K)	T Eq. (K)	T diff. (mK)
27	588.7109	12.31536	12.31521	0.16
28	556.9396	13.31142	13.31175	-0.33
29	529.4970	14.29626	14.29626	0.00
30	505.4585	15.27147	15.27098	0.48
31	484.0757	16.24031	16.24100	-0.70
32	464.9145	17.20508	17.20499	0.09
33	447.6005	18.16368	18.16363	0.04
34	431.7294	19.12564	19.12467	0.97
35	417.0529	20.09161	20.09174	-0.13
36	402.2085	21.15538	21.15535	0.02
37	382.3535	22.72942	22.73016	-0.75
38	364.1540	24.34858	24.34938	-0.80
39	347.8077	25.97003	25.96991	0.12
40	333.0536	27.58877	27.58816	0.60
41	319.6460	29.20487	29.20510	-0.23
42	306.0225	31.01336	31.01100	2.37
43	291.6322	33.12182	33.12319	-1.37
44	273.5407	36.12844	36.12954	-1.10
45	257.7612	39.13414	39.13355	0.59
46	243.8771	42.13056	42.13170	-1.14
47	231.4980	45.13986	45.13887	0.99
48	220.4450	48.13698	48.13755	-0.57
49	213.7066	50.13279	50.13253	0.27
50	198.6551	55.12679	55.12460	2.19
51	185.7160	60.12354	60.12411	-0.57
52	174.4724	65.12256	65.12494	-2.38
53	164.5970	70.12718	70.12850	-1.31
54	155.8627	75.12698	75.12364	3.35
55	148.0556	80.12363	80.12281	0.82
56	141.0346	85.11884	85.12135	-2.50
57	134.6839	90.11707	90.11626	0.81

Order of Fit = 6 RMS error of fit = 1.22 mK
Largest absolute error = 3.35 mK at data point no. 54

POLYNOMIAL EQUATION

Calibration Report: 939801 Sales Order: 113048
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X117656
Sensor Type: Cernox Resistor Temperature Range: 1.40 K to 325 K

Polynomial Type: Chebychev
Useful Range of Fit:

80.1 K	to	325 K
148.1 ohms	to	45.69 ohms

Lower and Upper limits of Log(Resistance) used in computing Chebychev coefficients:
ZL = 1.65427407116 ZU = 2.21642185223

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	176.299896	1.5993E-03	110233.61
1	-126.295899	2.4837E-03	-50849.40
2	23.105308	2.3609E-03	9786.57
3	-3.586632	2.2368E-03	-1603.46
4	0.737024	2.1286E-03	346.25
5	-0.154417	2.1409E-03	-72.13
6	0.027315	2.1134E-03	12.92
7	-0.006635	2.0599E-03	-3.22
8	0.003655	2.0455E-03	1.79

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.

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POLYNOMIAL EQUATION

Calibration Report: 939801
Sensor Model: CX-1050-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 113048
Serial Number: X117656
Temperature Range: 1.40 K to 325 K

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

	R Meas. (W)	T Meas. (K)	T Eq. (K)	T diff. (mK)
53	164.5970	70.12850	70.12961	-1.12
54	155.8627	75.12364	75.12087	2.76
55	148.0556	80.12281	80.12202	0.79
56	141.0346	85.11884	85.12267	-3.82
57	134.6839	90.11707	90.11960	-2.53
58	128.9143	95.11213	95.10756	4.57
59	123.6241	100.10861	100.10933	-0.72
60	114.2905	110.11216	110.11246	-0.30
61	106.3082	120.11833	120.11574	2.59
62	99.40332	130.11161	130.11016	1.45
63	93.34919	140.12343	140.13052	-7.09
64	88.02396	150.12648	150.12431	2.18
65	83.28815	160.12979	160.12914	0.65
66	79.05462	170.13460	170.13678	-2.18
67	75.25286	180.13870	180.13938	-0.68
68	71.82286	190.14252	190.13612	6.40
69	68.70784	200.15031	200.15123	-0.91
70	65.88058	210.14794	210.14009	7.84
71	63.29241	220.14636	220.15337	-7.01
72	60.92155	230.16041	230.16653	-6.12
73	58.74509	240.16938	240.17110	-1.72
74	56.74020	250.16556	250.17358	-8.02
75	54.89475	260.15908	260.13979	19.30
76	53.17347	270.17412	270.17978	-5.66
77	51.58196	280.17924	280.18587	-6.63
78	50.10738	290.17537	290.15612	19.26
79	48.72268	300.19515	300.20758	-12.43
80	47.43891	310.19035	310.19502	-4.68
81	46.82838	315.19871	315.19283	5.88
82	46.23541	320.20267	320.21189	-9.22
83	45.55012	326.23496	326.22683	8.13
84	45.11013	330.21583	330.21678	-0.95

Order of Fit = 8 RMS error of fit = 6.98 mK
Largest absolute error = 19.30 mK at data point no. 75

INTERPOLATION TABLE

Calibration Report: 939801 Sales Order: 113048

Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X117656

Sensor Type: Cernox Resistor 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	5871.42	-7231.8	-1.7244	15.50	500.199	-22.667	-0.70240
1.500	5224.14	-5783.0	-1.6605	16.00	489.177	-21.442	-0.70134
1.600	4702.96	-4691.2	-1.5960	16.50	478.738	-20.329	-0.70064
1.700	4277.14	-3862.9	-1.5353	17.00	468.832	-19.309	-0.70017
1.800	3923.81	-3232.5	-1.4829	17.50	459.414	-18.375	-0.69995
1.900	3625.96	-2743.3	-1.4375	18.00	450.445	-17.515	-0.69993
2.000	3371.81	-2354.8	-1.3967	18.50	441.888	-16.723	-0.70012
2.100	3152.49	-2042.1	-1.3603	19.00	433.712	-15.990	-0.70047
2.200	2961.48	-1786.6	-1.3272	19.50	425.889	-15.310	-0.70098
2.300	2793.70	-1575.3	-1.2969	20.00	418.394	-14.678	-0.70161
2.400	2645.28	-1398.5	-1.2688	21.00	404.299	-13.539	-0.70323
2.500	2513.09	-1249.3	-1.2428	22.00	391.269	-12.542	-0.70519
2.600	2394.69	-1122.2	-1.2184	23.00	379.176	-11.663	-0.70744
2.700	2288.05	-1013.2	-1.1956	24.00	367.911	-10.882	-0.70984
2.800	2191.55	-919.10	-1.1743	25.00	357.385	-10.184	-0.71240
2.900	2103.82	-837.34	-1.1542	26.00	347.520	-9.5571	-0.71502
3.000	2023.73	-765.89	-1.1354	27.00	338.250	-8.9910	-0.71769
3.100	1950.35	-703.15	-1.1176	28.00	329.520	-8.4778	-0.72038
3.200	1882.86	-647.76	-1.1009	29.00	321.280	-8.0103	-0.72304
3.300	1820.59	-598.65	-1.0851	30.00	313.486	-7.5831	-0.72569
3.400	1762.95	-554.92	-1.0702	31.00	306.102	-7.1913	-0.72829
3.500	1709.45	-515.82	-1.0561	32.00	299.093	-6.8309	-0.73084
3.600	1659.65	-480.72	-1.0428	33.00	292.430	-6.4985	-0.73334
3.700	1613.19	-449.12	-1.0301	34.00	286.087	-6.1911	-0.73578
3.800	1569.73	-420.56	-1.0181	35.00	280.041	-5.9057	-0.73811
3.900	1528.99	-394.66	-1.0067	36.00	274.269	-5.6408	-0.74039
4.000	1490.72	-371.11	-0.99578	37.00	268.753	-5.3943	-0.74264
4.200	1420.73	-330.04	-0.97569	38.00	263.475	-5.1639	-0.74477
4.400	1358.27	-295.49	-0.95723	39.00	258.420	-4.9488	-0.74685
4.600	1302.19	-266.13	-0.94010	40.00	253.573	-4.7474	-0.74888
4.800	1251.52	-241.13	-0.92482	42.00	244.453	-4.3809	-0.75269
5.000	1205.51	-219.52	-0.91050	44.00	236.021	-4.0568	-0.75628
5.200	1163.52	-200.79	-0.89737	46.00	228.202	-3.7686	-0.75965
5.400	1125.04	-184.38	-0.88498	48.00	220.927	-3.5109	-0.76279
5.600	1089.63	-169.99	-0.87366	50.00	214.140	-3.2798	-0.76580
5.800	1056.93	-157.30	-0.86317	52.00	207.793	-3.0714	-0.76863
6.000	1026.62	-145.96	-0.85307	54.00	201.841	-2.8828	-0.77126
6.500	959.727	-122.71	-0.83112	56.00	196.249	-2.7120	-0.77388
7.000	903.046	-104.76	-0.81202	58.00	190.983	-2.5563	-0.77632
7.500	854.317	-90.680	-0.79607	60.00	186.015	-2.4142	-0.77870
8.000	811.917	-79.332	-0.78168	65.00	174.735	-2.1085	-0.78435
8.500	774.619	-70.157	-0.76984	70.00	164.836	-1.8596	-0.78969
9.000	741.503	-62.541	-0.75909	75.00	156.067	-1.6544	-0.79504
9.500	711.863	-56.204	-0.75006	77.35	152.279	-1.5702	-0.79756
10.00	685.140	-50.831	-0.74191	80.00	148.236	-1.4824	-0.80003
10.50	660.896	-46.267	-0.73506	85.00	141.198	-1.3371	-0.80490
11.00	638.771	-42.328	-0.72892	90.00	134.829	-1.2137	-0.81019
11.50	618.478	-38.924	-0.72375	95.00	129.033	-1.1071	-0.81508
12.00	599.777	-35.945	-0.71917	100.0	123.735	-1.0144	-0.81981
12.50	582.472	-33.334	-0.71535	105.0	118.870	-0.93314	-0.82426
13.00	566.394	-31.021	-0.71201	110.0	114.387	-0.86157	-0.82853
13.50	551.407	-28.970	-0.70927	115.0	110.241	-0.79819	-0.83264
14.00	537.388	-27.138	-0.70699	120.0	106.394	-0.74169	-0.83654
14.50	524.236	-25.499	-0.70527	125.0	102.814	-0.69112	-0.84025
15.00	511.864	-24.014	-0.70373	130.0	99.4744	-0.64561	-0.84372

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INTERPOLATION TABLE

Calibration Report: 939801 Sales Order: 113048

Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X117656

Sensor Type: Cernox Resistor 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
135.0	96.3508	-0.60449	-0.84697	235.0	59.8474	-0.21777	-0.85509
140.0	93.4232	-0.56718	-0.84994	240.0	58.7808	-0.20896	-0.85317
145.0	90.6735	-0.53320	-0.85266	245.0	57.7570	-0.20064	-0.85110
150.0	88.0863	-0.50213	-0.85507	250.0	56.7736	-0.19278	-0.84888
155.0	85.6478	-0.47366	-0.85720	255.0	55.8285	-0.18533	-0.84652
160.0	83.3459	-0.44748	-0.85903	260.0	54.9197	-0.17828	-0.84401
165.0	81.1696	-0.42334	-0.86056	265.0	54.0451	-0.17159	-0.84138
170.0	79.1094	-0.40104	-0.86179	270.0	53.2032	-0.16525	-0.83861
175.0	77.1565	-0.38038	-0.86274	273.15	52.6887	-0.16141	-0.83681
180.0	75.3032	-0.36121	-0.86341	275.0	52.3921	-0.15922	-0.83572
185.0	73.5422	-0.34338	-0.86380	280.0	51.6105	-0.15349	-0.83271
190.0	71.8673	-0.32678	-0.86393	285.0	50.8568	-0.14804	-0.82959
195.0	70.2726	-0.31129	-0.86381	290.0	50.1297	-0.14284	-0.82636
200.0	68.7527	-0.29682	-0.86344	295.0	49.4279	-0.13790	-0.82302
205.0	67.3028	-0.28328	-0.86286	300.0	48.7503	-0.13318	-0.81958
210.0	65.9185	-0.27059	-0.86205	305.0	48.0957	-0.12868	-0.81604
215.0	64.5956	-0.25869	-0.86103	310.0	47.4631	-0.12439	-0.81241
220.0	63.3303	-0.24751	-0.85982	315.0	46.8516	-0.12028	-0.80869
225.0	62.1193	-0.23700	-0.85842	320.0	46.2600	-0.11636	-0.80489
230.0	60.9593	-0.22710	-0.85684	325.0	45.6877	-0.11260	-0.80100

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Calibration Report: 939801 Sales Order: 113048
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X117656
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:	49.0 Ω
Liquid Nitrogen:	152 Ω
Liquid Helium:	1416 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.

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BREAKPOINTS CUBIC SPLINE FORMAT

Calibration Report: 939801 Sales Order: 113048
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X117656
Sensor Type: Cernox Resistor Temperature Range: 1.40 K to 325 K

Sensor Model: CX-1050-SD-HT-1.4L
Serial Number: X117656
Data Format: 7 (Ohms/Kelvin)
Setpoint Limit: 325

Measurement (ohms)	Temp (K)	Curvature	Measurement (ohms)	Temp (K)	Curvature
4.51101E+01	3.30217E+02	5.42454E-01	5.29497E+02	1.42963E+01	1.80975E-04
4.55501E+01	3.26227E+02	5.21137E-01	5.56940E+02	1.33114E+01	1.53780E-04
4.62354E+01	3.20212E+02	4.87936E-01	5.88711E+02	1.23154E+01	1.27236E-04
4.68284E+01	3.15193E+02	4.62127E-01	6.26307E+02	1.13021E+01	1.02674E-04
4.74389E+01	3.10195E+02	4.36837E-01	6.71779E+02	1.02697E+01	8.00764E-05
4.87227E+01	3.00208E+02	3.90250E-01	7.27222E+02	9.23426E+00	6.01375E-05
5.01074E+01	2.90156E+02	3.47720E-01	7.96991E+02	8.19277E+00	4.28957E-05
5.15820E+01	2.80186E+02	3.09266E-01	8.87661E+02	7.15019E+00	2.88290E-05
5.31735E+01	2.70180E+02	2.74196E-01	9.81605E+02	6.32682E+00	1.99217E-05
5.48948E+01	2.60140E+02	2.42290E-01	1.08841E+03	5.60721E+00	1.36168E-05
5.67402E+01	2.50174E+02	2.13612E-01	1.18603E+03	5.09056E+00	9.99915E-06
5.87451E+01	2.40171E+02	1.87584E-01	1.28124E+03	4.68030E+00	7.50471E-06
6.09216E+01	2.30167E+02	1.64100E-01	1.42097E+03	4.19928E+00	5.15335E-06
6.32924E+01	2.20153E+02	1.42939E-01	1.49109E+03	3.99900E+00	4.38998E-06
6.58806E+01	2.10140E+02	1.23941E-01	1.57013E+03	3.79904E+00	3.63149E-06
6.87078E+01	2.00151E+02	1.06974E-01	1.66028E+03	3.59871E+00	2.97765E-06
7.18229E+01	1.90136E+02	9.17992E-02	1.76339E+03	3.39920E+00	2.40178E-06
7.52529E+01	1.80139E+02	7.83494E-02	1.88270E+03	3.20025E+00	1.90487E-06
7.90546E+01	1.70137E+02	6.64558E-02	2.02260E+03	3.00148E+00	1.47945E-06
8.32882E+01	1.60129E+02	5.59982E-02	2.19187E+03	2.79965E+00	1.11646E-06
8.80240E+01	1.50124E+02	4.68617E-02	2.39652E+03	2.59836E+00	8.19296E-07
9.33492E+01	1.40131E+02	3.89250E-02	2.64519E+03	2.40006E+00	5.83905E-07
9.94033E+01	1.30110E+02	3.20333E-02	2.96166E+03	2.19990E+00	3.98677E-07
1.06308E+02	1.20116E+02	2.60993E-02	3.36942E+03	2.00101E+00	2.60144E-07
1.14291E+02	1.10112E+02	2.09554E-02	3.92144E+03	1.80073E+00	1.58914E-07
1.23624E+02	1.00109E+02	1.65652E-02	4.70239E+03	1.60012E+00	8.75094E-08
1.28914E+02	9.51076E+01	1.46544E-02	5.86630E+03	1.40071E+00	4.19409E-08
1.34684E+02	9.01196E+01	1.28136E-02	6.67513E+03	1.30160E+00	3.14842E-08
1.41035E+02	8.51227E+01	1.11714E-02	7.75751E+03	1.19999E+00	1.74909E-08
1.48056E+02	8.01228E+01	9.70087E-03			
1.55863E+02	7.51236E+01	8.27111E-03			
1.64597E+02	7.01285E+01	7.01857E-03			
1.74472E+02	6.51249E+01	5.86508E-03			
1.85716E+02	6.01241E+01	4.83263E-03			
1.98655E+02	5.51246E+01	3.91126E-03			
2.13707E+02	5.01325E+01	3.11340E-03			
2.20445E+02	4.81376E+01	2.83256E-03			
2.31498E+02	4.51389E+01	2.42236E-03			
2.43877E+02	4.21317E+01	2.05514E-03			
2.57761E+02	3.91335E+01	1.72474E-03			
2.73541E+02	3.61295E+01	1.42925E-03			
2.91632E+02	3.31232E+01	1.16986E-03			
3.06023E+02	3.10110E+01	1.00844E-03			
3.19646E+02	2.92051E+01	8.80716E-04			
3.33054E+02	2.75882E+01	7.75614E-04			
3.47808E+02	2.59699E+01	6.78354E-04			
3.64154E+02	2.43494E+01	5.88943E-04			
3.82353E+02	2.27302E+01	5.06961E-04			
4.02208E+02	2.11554E+01	4.34375E-04			
4.17053E+02	2.00917E+01	3.89089E-04			
4.31729E+02	1.91247E+01	3.49690E-04			
4.47600E+02	1.81636E+01	3.12669E-04			
4.64915E+02	1.72050E+01	2.77684E-04			
4.84076E+02	1.62410E+01	2.44194E-04			
5.05459E+02	1.52710E+01	2.12711E-04			

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BREAKPOINTS 340 FORMAT

Calibration Report: 939801 Sales Order: 113048
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X117656
Sensor Type: Cernox Resistor Temperature Range: 1.40 K to 325 K

Name: CX-1050-SD-HT-1.4L
Serial Number: X117656
Format: 4 ;Log Ohms/Kelvin
Limit: 325.0
Coefficient: 1 ;Negative

Point 1: 1.65978,325.000	Point 51: 2.12011, 92.500	Point 101: 2.73356, 13.850
Point 2: 1.66629,319.000	Point 52: 2.12977, 90.000	Point 102: 2.74603, 13.300
Point 3: 1.67239,313.500	Point 53: 2.13966, 87.500	Point 103: 2.75908, 12.750
Point 4: 1.67863,308.000	Point 54: 2.14981, 85.000	Point 104: 2.77152, 12.250
Point 5: 1.68502,302.500	Point 55: 2.16023, 82.500	Point 105: 2.78453, 11.750
Point 6: 1.69155,297.000	Point 56: 2.17093, 80.000	Point 106: 2.79819, 11.250
Point 7: 1.69823,291.500	Point 57: 2.18195, 77.500	Point 107: 2.81112, 10.800
Point 8: 1.70508,286.000	Point 58: 2.19329, 75.000	Point 108: 2.82468, 10.350
Point 9: 1.71208,280.500	Point 59: 2.20262, 73.000	Point 109: 2.83896, 9.900
Point 10: 1.71925,275.000	Point 60: 2.21217, 71.000	Point 110: 2.85405, 9.450
Point 11: 1.72660,269.500	Point 61: 2.22197, 69.000	Point 111: 2.87004, 9.000
Point 12: 1.73344,264.500	Point 62: 2.23203, 67.000	Point 112: 2.88513, 8.600
Point 13: 1.74042,259.500	Point 63: 2.24236, 65.000	Point 113: 2.90108, 8.200
Point 14: 1.74757,254.500	Point 64: 2.25299, 63.000	Point 114: 2.91806, 7.800
Point 15: 1.75487,249.500	Point 65: 2.26393, 61.000	Point 115: 2.93618, 7.400
Point 16: 1.76235,244.500	Point 66: 2.27520, 59.000	Point 116: 2.95313, 7.050
Point 17: 1.77000,239.500	Point 67: 2.28683, 57.000	Point 117: 2.97117, 6.700
Point 18: 1.77782,234.500	Point 68: 2.29883, 55.000	Point 118: 2.99051, 6.350
Point 19: 1.78584,229.500	Point 69: 2.30998, 53.200	Point 119: 3.01253, 5.980
Point 20: 1.79404,224.500	Point 70: 2.32147, 51.400	Point 120: 3.03313, 5.660
Point 21: 1.80245,219.500	Point 71: 2.33334, 49.600	Point 121: 3.05391, 5.360
Point 22: 1.81106,214.500	Point 72: 2.34560, 47.800	Point 122: 3.07632, 5.060
Point 23: 1.81988,209.500	Point 73: 2.35829, 46.000	Point 123: 3.10064, 4.760
Point 24: 1.82893,204.500	Point 74: 2.37143, 44.200	Point 124: 3.12536, 4.480
Point 25: 1.83821,199.500	Point 75: 2.38506, 42.400	Point 125: 3.15034, 4.220
Point 26: 1.84773,194.500	Point 76: 2.39763, 40.800	Point 126: 3.17116, 4.020
Point 27: 1.85750,189.500	Point 77: 2.41063, 39.200	Point 127: 3.19109, 3.840
Point 28: 1.86753,184.500	Point 78: 2.42412, 37.600	Point 128: 3.21244, 3.660
Point 29: 1.87680,180.000	Point 79: 2.43813, 36.000	Point 129: 3.23405, 3.490
Point 30: 1.88629,175.500	Point 80: 2.45179, 34.500	Point 130: 3.25723, 3.320
Point 31: 1.89601,171.000	Point 81: 2.46598, 33.000	Point 131: 3.28072, 3.160
Point 32: 1.90599,166.500	Point 82: 2.48075, 31.500	Point 132: 3.30599, 3.000
Point 33: 1.91623,162.000	Point 83: 2.49513, 30.100	Point 133: 3.33162, 2.850
Point 34: 1.92674,157.500	Point 84: 2.51009, 28.700	Point 134: 3.35928, 2.700
Point 35: 1.93753,153.000	Point 85: 2.52574, 27.300	Point 135: 3.38937, 2.550
Point 36: 1.94862,148.500	Point 86: 2.54093, 26.000	Point 136: 3.41998, 2.410
Point 37: 1.96002,144.000	Point 87: 2.55681, 24.700	Point 137: 3.45091, 2.280
Point 38: 1.97175,139.500	Point 88: 2.57347, 23.400	Point 138: 3.48459, 2.150
Point 39: 1.98383,135.000	Point 89: 2.58965, 22.200	Point 139: 3.52156, 2.020
Point 40: 1.99488,131.000	Point 90: 2.60663, 21.000	Point 140: 3.55915, 1.900
Point 41: 2.00623,127.000	Point 91: 2.62004, 20.100	Point 141: 3.60058, 1.780
Point 42: 2.01791,123.000	Point 92: 2.63083, 19.400	Point 142: 3.64277, 1.670
Point 43: 2.02993,119.000	Point 93: 2.64201, 18.700	Point 143: 3.68963, 1.560
Point 44: 2.04232,115.000	Point 94: 2.65277, 18.050	Point 144: 3.74222, 1.450
Point 45: 2.05509,111.000	Point 95: 2.66391, 17.400	Point 145: 3.76879, 1.400
Point 46: 2.06828,107.000	Point 96: 2.67549, 16.750	
Point 47: 2.08192,103.000	Point 97: 2.68659, 16.150	
Point 48: 2.09248,100.000	Point 98: 2.69812, 15.550	
Point 49: 2.10148, 97.500	Point 99: 2.71014, 14.950	
Point 50: 2.11069, 95.000	Point 100: 2.72161, 14.400	

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BREAKPOINTS 91C/93C/330 FORMAT

Calibration Report: 939801 Sales Order: 113048
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X117656
Sensor Type: Cernox Resistor Temperature Range: 1.40 K to 325 K

Interpolation Method: Lagrangian
Limit: 325.0 (Kelvin)
Format: 4 (Log Ohms/Kelvin)
Number of Breakpoints: 52

No.	Units	Temperature (K)	No.	Units	Temperature (K)
1	1.65980	325.0	31	2.79685	11.3
2	1.66087	324.0	32	2.84562	9.7
3	1.67750	309.0	33	2.89305	8.4
4	1.69519	294.0	34	2.94100	7.3
5	1.71403	279.0	35	2.98776	6.4
6	1.73414	264.0	36	3.03728	5.6
7	1.75562	249.0	37	3.08117	5.0
8	1.77863	234.0	38	3.13299	4.4
9	1.80331	219.0	39	3.17340	4.0
10	1.82987	204.0	40	3.22002	3.6
11	1.85851	189.0	41	3.26021	3.3
12	1.88952	174.0	42	3.30615	3.0
13	1.92322	159.0	43	3.35947	2.7
14	1.96004	144.0	44	3.40021	2.5
15	2.00054	129.0	45	3.44618	2.3
16	2.04550	114.0	46	3.49865	2.1
17	2.09607	99.0	47	3.52786	2.0
18	2.15396	84.0	48	3.55942	1.9
19	2.22198	69.0	49	3.59371	1.8
20	2.27238	59.5	50	3.63115	1.7
21	2.33070	50.0	51	3.71801	1.5
22	2.36556	45.0	52	3.76874	1.4
23	2.40410	40.0			
24	2.44722	35.0			
25	2.49622	30.0			
26	2.54822	25.4			
27	2.59809	21.6			
28	2.64862	18.3			
29	2.69914	15.5			
30	2.74840	13.2			

Temperature for Resistance Decades:

Res. (Ohms)	Temp. (K)
100	129.190
1000	6.188

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BREAKPOINTS 234 FORMAT

Calibration Report: 939801 Sales Order: 113048

Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X117656

Sensor Type: Cernox Resistor Temperature Range: 1.40 K to 325 K

Maximum Temperature Error:

1.4 - 10 K:	0.009 K
10 - 20 K:	0.006 K
20 - 40 K:	0.010 K
40 - 100 K:	0.021 K
> 100 K:	0.101 K

BP #	Temp. (K)	Res. (W)	Log10 Res.	BP #	Temp. (K)	Res. (W)	Log10 Res.
1	324.813	45.70882	1.660	46	24.451	363.0781	2.560
2	306.820	47.86301	1.680	47	22.913	380.1894	2.580
3	290.077	50.11872	1.700	48	21.466	398.1072	2.600
4	274.444	52.48075	1.720	49	20.104	416.8694	2.620
5	259.807	54.95409	1.740	50	18.826	436.5158	2.640
6	246.066	57.54399	1.760	51	17.627	457.0882	2.660
7	233.138	60.25596	1.780	52	16.505	478.6301	2.680
8	220.952	63.09573	1.800	53	15.457	501.1872	2.700
9	209.444	66.06934	1.820	54	14.478	524.8075	2.720
10	198.560	69.18310	1.840	55	13.565	549.5409	2.740
11	188.252	72.44360	1.860	56	12.714	575.4399	2.760
12	178.477	75.85776	1.880	57	11.923	602.5596	2.780
13	169.197	79.43282	1.900	58	11.188	630.9573	2.800
14	160.380	83.17638	1.920	59	10.504	660.6934	2.820
15	151.995	87.09636	1.940	60	9.870	691.8310	2.840
16	144.016	91.20108	1.960	61	9.281	724.4360	2.860
17	136.422	95.49926	1.980	62	8.735	758.5776	2.880
18	129.190	100.0000	2.000	63	8.228	794.3282	2.900
19	122.304	104.7129	2.020	64	7.758	831.7638	2.920
20	115.747	109.6478	2.040	65	7.321	870.9636	2.940
21	109.505	114.8154	2.060	66	6.916	912.0108	2.960
22	103.564	120.2264	2.080	67	6.539	954.9926	2.980
23	97.911	125.8925	2.100	68	6.189	1000.000	3.000
24	92.534	131.8257	2.120	69	5.560	1096.478	3.040
25	87.420	138.0384	2.140	70	5.015	1202.264	3.080
26	82.559	144.5440	2.160	71	4.541	1318.257	3.120
27	77.942	151.3561	2.180	72	4.127	1445.440	3.160
28	73.560	158.4893	2.200	73	3.764	1584.893	3.200
29	69.400	165.9587	2.220	74	3.446	1737.801	3.240
30	65.456	173.7801	2.240	75	3.166	1905.461	3.280
31	61.716	181.9701	2.260	76	2.917	2089.296	3.320
32	58.172	190.5461	2.280	77	2.697	2290.868	3.360
33	54.813	199.5262	2.300	78	2.501	2511.886	3.400
34	51.632	208.9296	2.320	79	2.325	2754.229	3.440
35	48.619	218.7762	2.340	80	2.168	3019.952	3.480
36	45.766	229.0868	2.360	81	2.026	3311.311	3.520
37	43.065	239.8833	2.380	82	1.898	3630.781	3.560
38	40.508	251.1886	2.400	83	1.783	3981.072	3.600
39	38.087	263.0268	2.420	84	1.678	4365.158	3.640
40	35.796	275.4229	2.440	85	1.583	4786.301	3.680
41	33.629	288.4032	2.460	86	1.496	5248.075	3.720
42	31.580	301.9952	2.480	87	1.416	5754.399	3.760
43	29.642	316.2278	2.500	88	1.343	6309.573	3.800
44	27.811	331.1311	2.520	89	1.276	6918.310	3.840
45	26.082	346.7369	2.540	90	1.214	7585.776	3.880

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