CALIBRATION CERTIFICATE
Report Number: 943107

Sensor Model: CX-1050-SD-HT-1.4L	Serial Number: X118798
Sensor Type: Cernox Resistor	Sales Order: 114692
Sensor Excitation: see *Test Data* page of report	Date: February 28, 2017
Temperature Range: 1.40 K to 325 K	Due: February 28, 2018

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

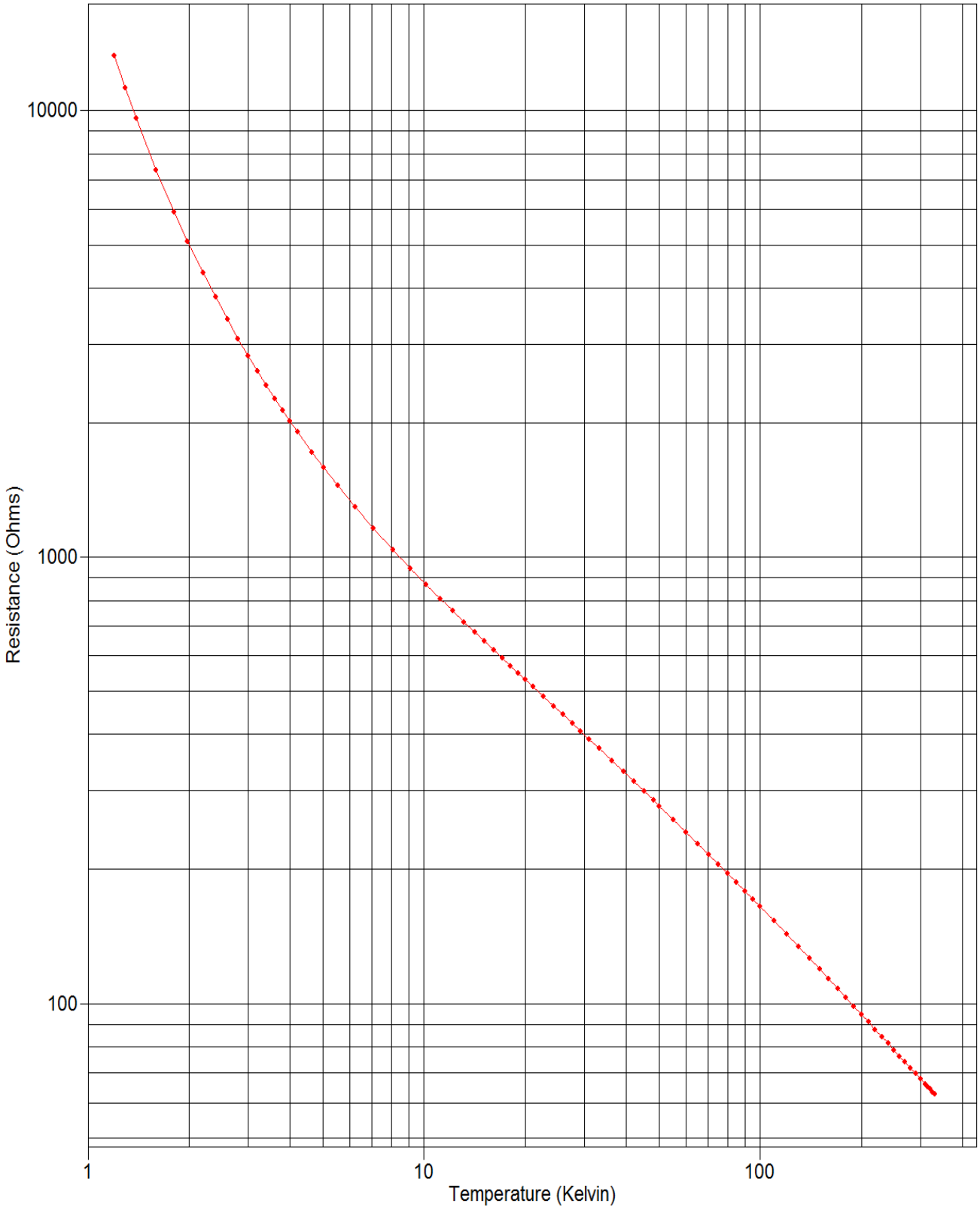
Approved by: John Krause
Metrology

Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville, OH 43082
Sales: (614) 891-2244 • Fax: (614) 891-1392 • sales@lakeshore.com • www.lakeshore.com

DATA PLOT

Calibration Report: 943107
Sensor Model: CX-1050-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 114692
Serial Number: X118798
Temperature Range: 1.40 K to 325 K



Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville, OH 43082
Sales: (614) 891-2244 • Fax: (614) 891-1392 • sales@lakeshore.com • www.lakeshore.com

TEST DATA

Calibration Report: 943107
Sensor Model: CX-1050-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 114692
Serial Number: X118798
Temperature Range: 1.40 K to 325 K

Index	Temp. (K)	Resistance (Ω)	Excitation	Index	Temp. (K)	Resistance (Ω)	Excitation
1	1.19867	13264.0	2mV±25%	46	42.1925	313.373	2mV±25%
2	1.29202	11196.7	2mV±25%	47	45.1890	298.163	2mV±25%
3	1.39442	9599.67	2mV±25%	48	48.1871	284.529	2mV±25%
4	1.59753	7361.22	2mV±25%	49	50.1808	276.244	2mV±25%
5	1.80764	5924.62	2mV±25%	50	55.1826	257.647	2mV±25%
6	1.98351	5088.22	2mV±25%	51	60.1781	241.682	2mV±25%
7	2.20123	4323.80	2mV±25%	52	65.1816	227.793	2mV±25%
8	2.39627	3815.01	2mV±25%	53	70.1740	215.600	2mV±25%
9	2.59826	3407.78	2mV±25%	54	75.1696	204.780	2mV±25%
10	2.79867	3085.95	2mV±25%	55	80.1592	195.108	2mV±25%
11	2.99939	2823.36	2mV±25%	56	85.1530	186.388	2mV±25%
12	3.19974	2605.28	2mV±25%	57	90.1521	178.478	2mV±25%
13	3.40162	2420.07	2mV±25%	58	95.1439	171.267	2mV±25%
14	3.59895	2265.06	2mV±25%	59	100.132	164.673	2mV±25%
15	3.79919	2129.42	2mV±25%	60	110.139	152.959	2mV±25%
16	3.99899	2011.70	2mV±25%	61	120.135	142.900	2mV±25%
17	4.19996	1907.78	2mV±25%	62	130.129	134.153	2mV±25%
18	4.64156	1720.05	2mV±25%	63	140.121	126.455	2mV±25%
19	5.04033	1584.53	2mV±25%	64	150.113	119.636	2mV±25%
20	5.54262	1446.17	2mV±25%	65	160.110	113.555	2mV±25%
21	6.25273	1294.34	2mV±25%	66	170.108	108.082	2mV±25%
22	7.06434	1162.35	2mV±25%	67	180.104	103.144	2mV±25%
23	8.08293	1038.41	2mV±25%	68	190.100	98.6755	2mV±25%
24	9.10653	943.521	2mV±25%	69	200.091	94.5946	2mV±25%
25	10.1329	868.289	2mV±25%	70	210.090	90.8683	2mV±25%
26	11.1549	807.314	2mV±25%	71	220.095	87.4448	2mV±25%
27	12.1704	756.680	2mV±25%	72	230.086	84.3006	2mV±25%
28	13.1760	714.159	2mV±25%	73	240.083	81.3988	2mV±25%
29	14.1687	677.620	2mV±25%	74	250.090	78.7020	2mV±25%
30	15.1585	645.760	2mV±25%	75	260.076	76.2163	2mV±25%
31	16.1372	617.676	2mV±25%	76	270.092	73.8908	2mV±25%
32	17.1174	592.581	2mV±25%	77	280.078	71.7377	2mV±25%
33	18.0958	569.912	2mV±25%	78	290.090	69.7246	2mV±25%
34	19.0778	549.233	2mV±25%	79	300.081	67.8355	2mV±25%
35	20.0560	530.390	2mV±25%	80	310.079	66.0737	2mV±25%
36	21.1325	511.349	2mV±25%	81	315.073	65.2324	2mV±25%
37	22.7188	486.172	2mV±25%	82	320.066	64.4135	2mV±25%
38	24.3349	463.344	2mV±25%	83	326.341	63.4302	2mV±25%
39	25.9729	442.702	2mV±25%	84	331.522	62.6418	2mV±25%
40	27.6082	424.102	2mV±25%				
41	29.2375	407.274	2mV±25%				
42	31.0638	390.194	2mV±25%				
43	33.1869	372.301	2mV±25%				
44	36.1992	349.911	2mV±25%				
45	39.1996	330.444	2mV±25%				

Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville, OH 43082
Sales: (614) 891-2244 • Fax: (614) 891-1392 • sales@lakeshore.com • www.lakeshore.com

Calibration Report: 943107 Sales Order: 114692
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X118798
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.

Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville, OH 43082
Sales: (614) 891-2244 • Fax: (614) 891-1392 • sales@lakeshore.com • www.lakeshore.com

POLYNOMIAL EQUATION

Calibration Report: 943107 Sales Order: 114692
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X118798
Sensor Type: Cernox Resistor Temperature Range: 1.40 K to 325 K

Polynomial Type: Chebychev
Useful Range of Fit:

1.40 K	to	14.2 K
9504 ohms	to	677.6 ohms

Lower and Upper limits of Log(Resistance) used in computing Chebychev coefficients:
ZL = 2.79076081831 ZU = 4.12267312414

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	5.485717	4.4276E-04	12389.90
1	-6.329013	7.0749E-04	-8945.76
2	2.836323	6.1667E-04	4599.45
3	-1.057400	6.2359E-04	-1695.68
4	0.332531	5.9548E-04	558.43
5	-0.084679	5.5631E-04	-152.22
6	0.015311	5.3722E-04	28.50

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.

Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville, OH 43082
Sales: (614) 891-2244 • Fax: (614) 891-1392 • sales@lakeshore.com • www.lakeshore.com

POLYNOMIAL EQUATION

Calibration Report: 943107 Sales Order: 114692
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X118798
Sensor Type: Cernox Resistor 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	13263.96	1.19867	1.19879	-0.12
2	11196.67	1.29202	1.29222	-0.20
3	9599.675	1.39442	1.39296	1.46
4	7361.222	1.59753	1.59988	-2.36
5	5924.618	1.80764	1.80790	-0.26
6	5088.222	1.98351	1.98174	1.77
7	4323.800	2.20123	2.20043	0.80
8	3815.011	2.39627	2.39663	-0.36
9	3407.777	2.59826	2.59847	-0.20
10	3085.946	2.79867	2.79860	0.08
11	2823.362	2.99939	2.99887	0.52
12	2605.280	3.19974	3.19929	0.45
13	2420.072	3.40162	3.40148	0.14
14	2265.062	3.59895	3.59978	-0.84
15	2129.416	3.79919	3.80079	-1.61
16	2011.696	3.99899	4.00106	-2.06
17	1907.776	4.19996	4.20228	-2.32
18	1720.050	4.64156	4.64080	0.76
19	1584.526	5.04033	5.03745	2.88
20	1446.168	5.54262	5.53934	3.28
21	1294.343	6.25273	6.24973	2.99
22	1162.347	7.06434	7.06596	-1.62
23	1038.410	8.08293	8.08495	-2.02
24	943.5209	9.10653	9.10872	-2.20
25	868.2894	10.13285	10.13477	-1.92
26	807.3135	11.15486	11.15531	-0.45
27	756.6796	12.17038	12.17067	-0.29
28	714.1588	13.17602	13.17227	3.74
29	677.6200	14.16870	14.16700	1.71
30	645.7604	15.15851	15.15652	1.99
31	617.6761	16.13722	16.14097	-3.75

Order of Fit = 6 RMS error of fit = 1.83 mK
Largest absolute error = -3.75 mK at data point no. 31

Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville, OH 43082
Sales: (614) 891-2244 • Fax: (614) 891-1392 • sales@lakeshore.com • www.lakeshore.com

POLYNOMIAL EQUATION

Calibration Report: 943107 Sales Order: 114692
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X118798
Sensor Type: Cernox Resistor Temperature Range: 1.40 K to 325 K

Polynomial Type: Chebychev
Useful Range of Fit:

14.2 K	to	80.2 K
677.6 ohms	to	195.1 ohms

Lower and Upper limits of Log(Resistance) used in computing Chebychev coefficients:
ZL = 2.25158566284 ZU = 2.8789120121

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	42.343923	2.7665E-04	153062.20
1	-37.791104	4.5166E-04	-83671.28
2	8.687090	4.1182E-04	21094.21
3	-1.193303	3.8661E-04	-3086.55
4	0.134955	3.7043E-04	364.33
5	-0.006483	3.4903E-04	-18.57
6	-0.005107	3.4772E-04	-14.69

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.

Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville, OH 43082
Sales: (614) 891-2244 • Fax: (614) 891-1392 • sales@lakeshore.com • www.lakeshore.com

POLYNOMIAL EQUATION

Calibration Report: 943107
Sensor Model: CX-1050-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 114692
Serial Number: X118798
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	756.6796	12.17067	12.16997	0.69
28	714.1588	13.17227	13.17340	-1.13
29	677.6200	14.16700	14.16816	-1.16
30	645.7604	15.15851	15.15644	2.06
31	617.6761	16.13722	16.13803	-0.81
32	592.5811	17.11740	17.11683	0.58
33	569.9125	18.09584	18.09559	0.25
34	549.2334	19.07776	19.07739	0.37
35	530.3898	20.05599	20.05525	0.75
36	511.3490	21.13250	21.13381	-1.31
37	486.1721	22.71881	22.71889	-0.08
38	463.3436	24.33490	24.33670	-1.79
39	442.7023	25.97290	25.97181	1.09
40	424.1025	27.60815	27.60728	0.87
41	407.2745	29.23752	29.23889	-1.36
42	390.1940	31.06380	31.06393	-0.13
43	372.3014	33.18687	33.18575	1.12
44	349.9113	36.19919	36.19743	1.77
45	330.4435	39.19955	39.20161	-2.05
46	313.3731	42.19248	42.19162	0.87
47	298.1626	45.18905	45.18904	0.01
48	284.5294	48.18706	48.18955	-2.49
49	276.2438	50.18081	50.17932	1.49
50	257.6474	55.18256	55.18101	1.55
51	241.6822	60.17813	60.18017	-2.03
52	227.7929	65.18163	65.18076	0.87
53	215.5996	70.17400	70.17448	-0.48
54	204.7797	75.16962	75.16855	1.07
55	195.1075	80.15921	80.15940	-0.20
56	186.3882	85.15303	85.15372	-0.69
57	178.4784	90.15206	90.15175	0.31

Order of Fit = 6 RMS error of fit = 1.20 mK
Largest absolute error = -2.49 mK at data point no. 48

Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville, OH 43082
Sales: (614) 891-2244 • Fax: (614) 891-1392 • sales@lakeshore.com • www.lakeshore.com

POLYNOMIAL EQUATION

Calibration Report: 943107 Sales Order: 114692
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X118798
Sensor Type: Cernox Resistor Temperature Range: 1.40 K to 325 K

Polynomial Type: Chebychev
Useful Range of Fit:

80.2 K	to	325 K
195.1 ohms	to	63.64 ohms

Lower and Upper limits of Log(Resistance) used in computing Chebychev coefficients:
ZL = 1.79686407389 ZU = 2.33364797503

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	177.645987	1.8792E-03	94532.31
1	-127.454073	2.9062E-03	-43855.25
2	22.606387	2.7955E-03	8086.70
3	-3.104050	2.6554E-03	-1168.97
4	0.578085	2.5279E-03	228.68
5	-0.109661	2.5289E-03	-43.36
6	0.015830	2.4931E-03	6.35
7	-0.004554	2.4037E-03	-1.89

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.

Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville, OH 43082
Sales: (614) 891-2244 • Fax: (614) 891-1392 • sales@lakeshore.com • www.lakeshore.com

POLYNOMIAL EQUATION

Calibration Report: 943107
Sensor Model: CX-1050-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 114692
Serial Number: X118798
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	215.5996	70.17448	70.17395	0.52
54	204.7797	75.16855	75.16991	-1.36
55	195.1075	80.15940	80.15955	-0.14
56	186.3882	85.15303	85.15228	0.75
57	178.4784	90.15206	90.14887	3.20
58	171.2672	95.14393	95.14609	-2.17
59	164.6733	100.13199	100.13308	-1.08
60	152.9585	110.13875	110.14022	-1.47
61	142.9003	120.13537	120.13552	-0.15
62	134.1530	130.12918	130.12347	5.71
63	126.4546	140.12067	140.12383	-3.16
64	119.6360	150.11340	150.11778	-4.37
65	113.5551	160.11037	160.10260	7.77
66	108.0824	170.10786	170.10950	-1.64
67	103.1440	180.10413	180.11272	-8.59
68	98.67547	190.10011	190.09150	8.62
69	94.59462	200.09146	200.09623	-4.77
70	90.86826	210.08964	210.08876	0.88
71	87.44481	220.09520	220.09595	-0.74
72	84.30061	230.08613	230.08348	2.65
73	81.39875	240.08309	240.07096	12.14
74	78.70201	250.09016	250.10295	-12.79
75	76.21630	260.07627	260.07276	3.52
76	73.89078	270.09154	270.10652	-14.98
77	71.73769	280.07797	280.07905	-1.09
78	69.72455	290.09027	290.06736	22.91
79	67.83547	300.08061	300.09065	-10.04
80	66.07370	310.07854	310.06920	9.34
81	65.23239	315.07327	315.06856	4.71
82	64.41350	320.06560	320.09026	-24.66
83	63.43015	326.34110	326.33445	6.64
84	62.64178	331.52248	331.51863	3.85

Order of Fit = 7 RMS error of fit = 8.43 mK
Largest absolute error = -24.66 mK at data point no. 82

Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville, OH 43082
Sales: (614) 891-2244 • Fax: (614) 891-1392 • sales@lakeshore.com • www.lakeshore.com

INTERPOLATION TABLE

Calibration Report: 943107 Sales Order: 114692
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X118798
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	9504.05	-13459	-1.9825	15.50	635.562	-29.082	-0.70924
1.500	8308.75	-10594	-1.9126	16.00	621.436	-27.450	-0.70674
1.600	7360.25	-8481.0	-1.8436	16.50	608.086	-25.974	-0.70479
1.700	6595.12	-6893.4	-1.7769	17.00	595.441	-24.626	-0.70308
1.800	5969.14	-5680.0	-1.7128	17.50	583.440	-23.393	-0.70166
1.900	5449.96	-4742.2	-1.6533	18.00	572.031	-22.262	-0.70050
2.000	5013.92	-4008.3	-1.5989	18.50	561.163	-21.222	-0.69962
2.100	4643.33	-3424.9	-1.5490	19.00	550.796	-20.261	-0.69892
2.200	4325.08	-2957.2	-1.5042	19.50	540.890	-19.373	-0.69843
2.300	4048.96	-2577.5	-1.4641	20.00	531.412	-18.549	-0.69810
2.400	3807.36	-2264.8	-1.4276	21.00	513.621	-17.069	-0.69788
2.500	3594.26	-2004.7	-1.3944	22.00	497.211	-15.778	-0.69811
2.600	3405.04	-1786.2	-1.3639	23.00	482.013	-14.643	-0.69872
2.700	3235.91	-1601.1	-1.3359	24.00	467.883	-13.638	-0.69956
2.800	3083.92	-1442.8	-1.3100	25.00	454.700	-12.743	-0.70064
2.900	2946.62	-1306.5	-1.2858	26.00	442.365	-11.941	-0.70184
3.000	2822.02	-1188.3	-1.2632	27.00	430.791	-11.219	-0.70314
3.100	2708.46	-1085.1	-1.2420	28.00	419.905	-10.566	-0.70453
3.200	2604.57	-994.60	-1.2220	29.00	409.641	-9.9718	-0.70594
3.300	2509.18	-914.75	-1.2030	30.00	399.943	-9.4305	-0.70739
3.400	2421.32	-843.96	-1.1851	31.00	390.764	-8.9350	-0.70883
3.500	2340.13	-780.96	-1.1680	32.00	382.060	-8.4802	-0.71027
3.600	2264.90	-724.64	-1.1518	33.00	373.792	-8.0614	-0.71170
3.700	2195.01	-674.12	-1.1363	34.00	365.926	-7.6750	-0.71312
3.800	2129.91	-628.63	-1.1215	35.00	358.433	-7.3167	-0.71446
3.900	2069.14	-587.54	-1.1074	36.00	351.284	-6.9846	-0.71579
4.000	2012.28	-550.29	-1.0939	37.00	344.455	-6.6762	-0.71713
4.200	1908.88	-485.68	-1.0686	38.00	337.925	-6.3884	-0.71839
4.400	1817.30	-431.71	-1.0452	39.00	331.672	-6.1199	-0.71962
4.600	1735.64	-386.21	-1.0236	40.00	325.679	-5.8691	-0.72084
4.800	1662.35	-347.68	-1.0039	42.00	314.406	-5.4132	-0.72312
5.000	1596.20	-314.62	-0.98552	44.00	303.990	-5.0110	-0.72530
5.200	1536.19	-286.14	-0.96857	46.00	294.332	-4.6541	-0.72737
5.400	1481.50	-261.36	-0.95264	48.00	285.349	-4.3355	-0.72929
5.600	1431.43	-239.82	-0.93821	50.00	276.968	-4.0503	-0.73118
5.800	1385.40	-220.83	-0.92452	52.00	269.128	-3.7935	-0.73296
6.000	1342.95	-204.02	-0.91153	54.00	261.778	-3.5612	-0.73461
6.500	1249.88	-169.89	-0.88353	56.00	254.869	-3.3511	-0.73631
7.000	1171.74	-143.84	-0.85933	58.00	248.361	-3.1597	-0.73790
7.500	1105.06	-123.62	-0.83898	60.00	242.219	-2.9852	-0.73946
8.000	1047.44	-107.49	-0.82099	65.00	228.264	-2.6101	-0.74326
8.500	997.038	-94.535	-0.80593	70.00	216.001	-2.3050	-0.74699
9.000	952.526	-83.860	-0.79236	75.00	205.125	-2.0530	-0.75064
9.500	912.868	-75.023	-0.78074	77.35	200.424	-1.9495	-0.75239
10.00	877.274	-67.569	-0.77022	80.00	195.401	-1.8429	-0.75451
10.50	845.106	-61.262	-0.76114	85.00	186.641	-1.6655	-0.75850
11.00	815.866	-55.836	-0.75281	90.00	178.703	-1.5137	-0.76233
11.50	789.145	-51.159	-0.74553	95.00	171.469	-1.3832	-0.76636
12.00	764.607	-47.086	-0.73898	100.0	164.842	-1.2701	-0.77052
12.50	741.972	-43.523	-0.73324	105.0	158.744	-1.1712	-0.77469
13.00	721.021	-40.342	-0.72737	110.0	153.110	-1.0841	-0.77885
13.50	701.572	-37.512	-0.72183	115.0	147.886	-1.0069	-0.78301
14.00	683.448	-35.041	-0.71779	120.0	143.027	-0.93805	-0.78702
14.50	666.480	-32.871	-0.71514	125.0	138.494	-0.87629	-0.79091
15.00	650.547	-30.890	-0.71224	130.0	134.254	-0.82062	-0.79462

Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville, OH 43082
Sales: (614) 891-2244 • Fax: (614) 891-1392 • sales@lakeshore.com • www.lakeshore.com

INTERPOLATION TABLE

Calibration Report: 943107 Sales Order: 114692

Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X118798

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	130.279	-0.77024	-0.79815	235.0	82.8435	-0.29062	-0.82439
140.0	126.544	-0.72443	-0.80146	240.0	81.4186	-0.27946	-0.82378
145.0	123.028	-0.68265	-0.80457	245.0	80.0479	-0.26890	-0.82301
150.0	119.712	-0.64440	-0.80744	250.0	78.7287	-0.25889	-0.82211
155.0	116.579	-0.60929	-0.81010	255.0	77.4581	-0.24941	-0.82107
160.0	113.614	-0.57697	-0.81253	260.0	76.2338	-0.24040	-0.81990
165.0	110.805	-0.54713	-0.81474	265.0	75.0533	-0.23185	-0.81861
170.0	108.139	-0.51952	-0.81672	270.0	73.9146	-0.22372	-0.81721
175.0	105.606	-0.49393	-0.81848	273.15	73.2177	-0.21880	-0.81626
180.0	103.197	-0.47014	-0.82003	275.0	72.8155	-0.21598	-0.81568
185.0	100.902	-0.44799	-0.82138	280.0	71.7542	-0.20861	-0.81406
190.0	98.7146	-0.42734	-0.82251	285.0	70.7288	-0.20160	-0.81233
195.0	96.6267	-0.40804	-0.82345	290.0	69.7377	-0.19490	-0.81050
200.0	94.6321	-0.38997	-0.82419	295.0	68.7792	-0.18852	-0.80858
205.0	92.7250	-0.37305	-0.82474	300.0	67.8520	-0.18243	-0.80657
210.0	90.8999	-0.35716	-0.82511	305.0	66.9545	-0.17660	-0.80449
215.0	89.1519	-0.34222	-0.82530	310.0	66.0855	-0.17104	-0.80232
220.0	87.4763	-0.32816	-0.82532	315.0	65.2437	-0.16572	-0.80009
225.0	85.8689	-0.31492	-0.82517	320.0	64.4280	-0.16062	-0.79779
230.0	84.3259	-0.30242	-0.82486	325.0	63.6371	-0.15575	-0.79542

Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville, OH 43082
Sales: (614) 891-2244 • Fax: (614) 891-1392 • sales@lakeshore.com • www.lakeshore.com

Calibration Report: 943107 Sales Order: 114692
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X118798
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 305 K:	67.0 Ω
Liquid Nitrogen:	201 Ω
Liquid Helium:	1911 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.

Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville, OH 43082
Sales: (614) 891-2244 • Fax: (614) 891-1392 • sales@lakeshore.com • www.lakeshore.com

BREAKPOINTS CUBIC SPLINE FORMAT

Calibration Report: 943107 Sales Order: 114692
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X118798
Sensor Type: Cernox Resistor Temperature Range: 1.40 K to 325 K

Sensor Model: CX-1050-SD-HT-1.4L
Serial Number: X118798
Data Format: 7 (Ohms/Kelvin)
Setpoint Limit: 325

Measurement (ohms)	Temp (K)	Curvature	Measurement (ohms)	Temp (K)	Curvature
6.26418E+01	3.31519E+02	2.68275E-01	6.77620E+02	1.41670E+01	1.13324E-04
6.34302E+01	3.26334E+02	2.55915E-01	7.14159E+02	1.31723E+01	9.27053E-05
6.44135E+01	3.20090E+02	2.40497E-01	7.56680E+02	1.21707E+01	7.54637E-05
6.52324E+01	3.15069E+02	2.28890E-01	8.07314E+02	1.11553E+01	5.95532E-05
6.60737E+01	3.10069E+02	2.17444E-01	8.68289E+02	1.01348E+01	4.56306E-05
6.78355E+01	3.00091E+02	1.96133E-01	9.43521E+02	9.10872E+00	3.35978E-05
6.97246E+01	2.90067E+02	1.76419E-01	1.03841E+03	8.08495E+00	2.35224E-05
7.17377E+01	2.80079E+02	1.58275E-01	1.16235E+03	7.06596E+00	1.55021E-05
7.38908E+01	2.70107E+02	1.41604E-01	1.29434E+03	6.24973E+00	1.04419E-05
7.62163E+01	2.60073E+02	1.26214E-01	1.44617E+03	5.53934E+00	6.94639E-06
7.87020E+01	2.50103E+02	1.12218E-01	1.58453E+03	5.03745E+00	5.00630E-06
8.13988E+01	2.40071E+02	9.93621E-02	1.72005E+03	4.64080E+00	3.69572E-06
8.43006E+01	2.30083E+02	8.77144E-02	1.90778E+03	4.20228E+00	2.54200E-06
8.74448E+01	2.20096E+02	7.71360E-02	2.01170E+03	4.00106E+00	2.12719E-06
9.08683E+01	2.10089E+02	6.75402E-02	2.12942E+03	3.80079E+00	1.73028E-06
9.45946E+01	2.00096E+02	5.88890E-02	2.26506E+03	3.59978E+00	1.39264E-06
9.86755E+01	1.90091E+02	5.10915E-02	2.42007E+03	3.40148E+00	1.10410E-06
1.03144E+02	1.80113E+02	4.41111E-02	2.60528E+03	3.19929E+00	8.55375E-07
1.08082E+02	1.70109E+02	3.78509E-02	2.82336E+03	2.99887E+00	6.49969E-07
1.13555E+02	1.60103E+02	3.22712E-02	3.08595E+03	2.79860E+00	4.81677E-07
1.19636E+02	1.50118E+02	2.73293E-02	3.40778E+03	2.59847E+00	3.46197E-07
1.26455E+02	1.40124E+02	2.29579E-02	3.81501E+03	2.39663E+00	2.39356E-07
1.34153E+02	1.30123E+02	1.91113E-02	4.32380E+03	2.20043E+00	1.58483E-07
1.42900E+02	1.20136E+02	1.57520E-02	5.08822E+03	1.98174E+00	9.38623E-08
1.52959E+02	1.10140E+02	1.28161E-02	5.92462E+03	1.80790E+00	5.72080E-08
1.64673E+02	1.00133E+02	1.02912E-02	7.36122E+03	1.59988E+00	2.76527E-08
1.71267E+02	9.51461E+01	9.18603E-03	9.59967E+03	1.39296E+00	1.28084E-08
1.78478E+02	9.01489E+01	8.10720E-03	1.11967E+04	1.29222E+00	1.00348E-08
1.86388E+02	8.51523E+01	7.11701E-03	1.32640E+04	1.19879E+00	6.44456E-09
1.95108E+02	8.01594E+01	6.14856E-03			
2.04780E+02	7.51685E+01	5.32482E-03			
2.15600E+02	7.01745E+01	4.52215E-03			
2.27793E+02	6.51808E+01	3.80079E-03			
2.41682E+02	6.01802E+01	3.14518E-03			
2.57647E+02	5.51810E+01	2.55761E-03			
2.76244E+02	5.01793E+01	2.04375E-03			
2.84529E+02	4.81896E+01	1.86268E-03			
2.98163E+02	4.51890E+01	1.59654E-03			
3.13373E+02	4.21916E+01	1.35784E-03			
3.30444E+02	3.92016E+01	1.14174E-03			
3.49911E+02	3.61974E+01	9.46869E-04			
3.72301E+02	3.31857E+01	7.74649E-04			
3.90194E+02	3.10639E+01	6.66749E-04			
4.07274E+02	2.92389E+01	5.80721E-04			
4.24102E+02	2.76073E+01	5.09954E-04			
4.42702E+02	2.59718E+01	4.44319E-04			
4.63344E+02	2.43367E+01	3.84098E-04			
4.86172E+02	2.27189E+01	3.29414E-04			
5.11349E+02	2.11338E+01	2.80670E-04			
5.30390E+02	2.00552E+01	2.50105E-04			
5.49233E+02	1.90774E+01	2.23606E-04			
5.69912E+02	1.80956E+01	1.98609E-04			
5.92581E+02	1.71168E+01	1.74728E-04			
6.17676E+02	1.61380E+01	1.53323E-04			
6.45760E+02	1.51564E+01	1.28904E-04			

Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville, OH 43082
Sales: (614) 891-2244 • Fax: (614) 891-1392 • sales@lakeshore.com • www.lakeshore.com

BREAKPOINTS 340 FORMAT

Calibration Report: 943107 Sales Order: 114692
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X118798
Sensor Type: Cernox Resistor Temperature Range: 1.40 K to 325 K

Name: CX-1050-SD-HT-1.4L
Serial Number: X118798
Format: 4 ;Log Ohms/Kelvin
Limit: 325.0
Coefficient: 1 ;Negative

Point 1: 1.80370,325.000	Point 51: 2.25212, 90.000	Point 101: 2.84257, 13.650
Point 2: 1.81015,319.000	Point 52: 2.26143, 87.500	Point 102: 2.85429, 13.150
Point 3: 1.81619,313.500	Point 53: 2.27099, 85.000	Point 103: 2.86655, 12.650
Point 4: 1.82235,308.000	Point 54: 2.28081, 82.500	Point 104: 2.87941, 12.150
Point 5: 1.82865,302.500	Point 55: 2.29091, 80.000	Point 105: 2.89291, 11.650
Point 6: 1.83508,297.000	Point 56: 2.30130, 77.500	Point 106: 2.90570, 11.200
Point 7: 1.84164,291.500	Point 57: 2.30984, 75.500	Point 107: 2.91910, 10.750
Point 8: 1.84835,286.000	Point 58: 2.31859, 73.500	Point 108: 2.93323, 10.300
Point 9: 1.85521,280.500	Point 59: 2.32756, 71.500	Point 109: 2.94814, 9.850
Point 10: 1.86221,275.000	Point 60: 2.33677, 69.500	Point 110: 2.96393, 9.400
Point 11: 1.86938,269.500	Point 61: 2.34622, 67.500	Point 111: 2.97882, 9.000
Point 12: 1.87670,264.000	Point 62: 2.35595, 65.500	Point 112: 2.99455, 8.600
Point 13: 1.88420,258.500	Point 63: 2.36595, 63.500	Point 113: 3.01128, 8.200
Point 14: 1.89186,253.000	Point 64: 2.37625, 61.500	Point 114: 3.02910, 7.800
Point 15: 1.89971,247.500	Point 65: 2.38741, 59.400	Point 115: 3.04576, 7.450
Point 16: 1.90774,242.000	Point 66: 2.39839, 57.400	Point 116: 3.06346, 7.100
Point 17: 1.91597,236.500	Point 67: 2.40973, 55.400	Point 117: 3.08240, 6.750
Point 18: 1.92362,231.500	Point 68: 2.42028, 53.600	Point 118: 3.10272, 6.400
Point 19: 1.93144,226.500	Point 69: 2.43116, 51.800	Point 119: 3.12465, 6.050
Point 20: 1.93944,221.500	Point 70: 2.44240, 50.000	Point 120: 3.14564, 5.740
Point 21: 1.94762,216.500	Point 71: 2.45403, 48.200	Point 121: 3.16752, 5.440
Point 22: 1.95600,211.500	Point 72: 2.46607, 46.400	Point 122: 3.19118, 5.140
Point 23: 1.96457,206.500	Point 73: 2.47856, 44.600	Point 123: 3.21517, 4.860
Point 24: 1.97335,201.500	Point 74: 2.49007, 43.000	Point 124: 3.24121, 4.580
Point 25: 1.98234,196.500	Point 75: 2.50198, 41.400	Point 125: 3.26762, 4.320
Point 26: 1.99155,191.500	Point 76: 2.51511, 39.700	Point 126: 3.29642, 4.060
Point 27: 2.00100,186.500	Point 77: 2.52796, 38.100	Point 127: 3.32065, 3.860
Point 28: 2.01069,181.500	Point 78: 2.54133, 36.500	Point 128: 3.34266, 3.690
Point 29: 2.02064,176.500	Point 79: 2.55437, 35.000	Point 129: 3.36622, 3.520
Point 30: 2.03085,171.500	Point 80: 2.56793, 33.500	Point 130: 3.39155, 3.350
Point 31: 2.04028,167.000	Point 81: 2.58208, 32.000	Point 131: 3.41725, 3.190
Point 32: 2.04994,162.500	Point 82: 2.59587, 30.600	Point 132: 3.44494, 3.030
Point 33: 2.05985,158.000	Point 83: 2.61024, 29.200	Point 133: 3.47303, 2.880
Point 34: 2.07002,153.500	Point 84: 2.62420, 27.900	Point 134: 3.50340, 2.730
Point 35: 2.08046,149.000	Point 85: 2.63877, 26.600	Point 135: 3.53422, 2.590
Point 36: 2.09119,144.500	Point 86: 2.65404, 25.300	Point 136: 3.56767, 2.450
Point 37: 2.10222,140.000	Point 87: 2.66882, 24.100	Point 137: 3.60163, 2.320
Point 38: 2.11357,135.500	Point 88: 2.68432, 22.900	Point 138: 3.63869, 2.190
Point 39: 2.12526,131.000	Point 89: 2.70064, 21.700	Point 139: 3.67952, 2.060
Point 40: 2.13595,127.000	Point 90: 2.71641, 20.600	Point 140: 3.72123, 1.940
Point 41: 2.14694,123.000	Point 91: 2.72922, 19.750	Point 141: 3.76732, 1.820
Point 42: 2.15825,119.000	Point 92: 2.74016, 19.050	Point 142: 3.81435, 1.710
Point 43: 2.16990,115.000	Point 93: 2.75071, 18.400	Point 143: 3.86644, 1.600
Point 44: 2.18191,111.000	Point 94: 2.76164, 17.750	Point 144: 3.92459, 1.490
Point 45: 2.19431,107.000	Point 95: 2.77301, 17.100	Point 145: 3.97760, 1.400
Point 46: 2.20713,103.000	Point 96: 2.78393, 16.500	
Point 47: 2.21706,100.000	Point 97: 2.79528, 15.900	
Point 48: 2.22552, 97.500	Point 98: 2.80712, 15.300	
Point 49: 2.23417, 95.000	Point 99: 2.81845, 14.750	
Point 50: 2.24304, 92.500	Point 100: 2.83025, 14.200	

Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville, OH 43082
Sales: (614) 891-2244 • Fax: (614) 891-1392 • sales@lakeshore.com • www.lakeshore.com

BREAKPOINTS 91C/93C/330 FORMAT

Calibration Report: 943107 Sales Order: 114692
Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X118798
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: 53

No.	Units	Temperature (K)	No.	Units	Temperature (K)
1	1.80371	325.0	31	2.91461	10.9
2	1.80478	324.0	32	2.96400	9.4
3	1.82011	310.0	33	3.01571	8.1
4	1.83746	295.0	34	3.06355	7.1
5	1.85585	280.0	35	3.11517	6.2
6	1.87537	265.0	36	3.16314	5.5
7	1.89613	250.0	37	3.21177	4.9
8	1.91826	235.0	38	3.25943	4.4
9	1.94189	220.0	39	3.30369	4.0
10	1.96720	205.0	40	3.35505	3.6
11	1.99438	190.0	41	3.39953	3.3
12	2.02369	175.0	42	3.45056	3.0
13	2.05543	160.0	43	3.48910	2.8
14	2.09000	145.0	44	3.53212	2.6
15	2.12793	130.0	45	3.58062	2.4
16	2.16993	115.0	46	3.63599	2.2
17	2.21707	100.0	47	3.66683	2.1
18	2.27101	85.0	48	3.70018	2.0
19	2.33446	70.0	49	3.73639	1.9
20	2.38421	60.0	50	3.77591	1.8
21	2.44243	50.0	51	3.81922	1.7
22	2.47578	45.0	52	3.91954	1.5
23	2.51279	40.0	53	3.97791	1.4
24	2.55441	35.0			
25	2.60200	30.0			
26	2.65651	25.1			
27	2.70777	21.2			
28	2.75911	17.9			
29	2.81122	15.1			
30	2.86285	12.8			

Temperature for Resistance Decades:

Res. (Ohms)	Temp. (K)
100	187.032
1000	8.468

Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville, OH 43082
Sales: (614) 891-2244 • Fax: (614) 891-1392 • sales@lakeshore.com • www.lakeshore.com

BREAKPOINTS 234 FORMAT

Calibration Report: 943107 Sales Order: 114692

Sensor Model: CX-1050-SD-HT-1.4L Serial Number: X118798

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

Maximum Temperature Error:

1.4 - 10 K:	0.013 K
10 - 20 K:	0.006 K
20 - 40 K:	0.012 K
40 - 100 K:	0.023 K
> 100 K:	0.086 K

BP #	Temp. (K)	Res. (W)	Log10 Res.	BP #	Temp. (K)	Res. (W)	Log10 Res.
1	310.095	66.06934	1.820	46	20.362	524.8075	2.720
2	292.873	69.18310	1.840	47	19.062	549.5409	2.740
3	276.732	72.44360	1.860	48	17.848	575.4399	2.760
4	261.573	75.85776	1.880	49	16.715	602.5596	2.780
5	247.308	79.43282	1.900	50	15.660	630.9573	2.800
6	233.860	83.17638	1.920	51	14.678	660.6934	2.820
7	221.163	87.09636	1.940	52	13.765	691.8310	2.840
8	209.160	91.20108	1.960	53	12.916	724.4360	2.860
9	197.798	95.49926	1.980	54	12.129	758.5776	2.880
10	187.034	100.0000	2.000	55	11.400	794.3282	2.900
11	176.826	104.7129	2.020	56	10.722	831.7638	2.920
12	167.139	109.6478	2.040	57	10.094	870.9636	2.940
13	157.941	114.8154	2.060	58	9.511	912.0108	2.960
14	149.205	120.2264	2.080	59	8.971	954.9926	2.980
15	140.905	125.8925	2.100	60	8.469	1000.000	3.000
16	133.017	131.8257	2.120	61	7.570	1096.478	3.040
17	125.522	138.0384	2.140	62	6.795	1202.264	3.080
18	118.401	144.5440	2.160	63	6.124	1318.257	3.120
19	111.638	151.3561	2.180	64	5.542	1445.440	3.160
20	105.218	158.4893	2.200	65	5.036	1584.893	3.200
21	99.127	165.9587	2.220	66	4.594	1737.801	3.240
22	93.353	173.7801	2.240	67	4.207	1905.461	3.280
23	87.884	181.9701	2.260	68	3.866	2089.296	3.320
24	82.709	190.5461	2.280	69	3.565	2290.868	3.360
25	77.813	199.5262	2.300	70	3.297	2511.886	3.400
26	73.185	208.9296	2.320	71	3.059	2754.229	3.440
27	68.813	218.7762	2.340	72	2.845	3019.952	3.480
28	64.686	229.0868	2.360	73	2.654	3311.311	3.520
29	60.791	239.8833	2.380	74	2.482	3630.781	3.560
30	57.117	251.1886	2.400	75	2.327	3981.072	3.600
31	53.651	263.0268	2.420	76	2.187	4365.158	3.640
32	50.384	275.4229	2.440	77	2.060	4786.301	3.680
33	47.304	288.4032	2.460	78	1.944	5248.075	3.720
34	44.401	301.9952	2.480	79	1.839	5754.399	3.760
35	41.666	316.2278	2.500	80	1.743	6309.573	3.800
36	39.089	331.1311	2.520	81	1.655	6918.310	3.840
37	36.661	346.7369	2.540	82	1.574	7585.776	3.880
38	34.374	363.0781	2.560	83	1.499	8317.638	3.920
39	32.222	380.1894	2.580	84	1.430	9120.108	3.960
40	30.196	398.1072	2.600	85	1.365	10000.00	4.000
41	28.290	416.8694	2.620	86	1.225	12589.25	4.100
42	26.498	436.5158	2.640				
43	24.814	457.0882	2.660				
44	23.233	478.6301	2.680				
45	21.750	501.1872	2.700				

Lake Shore Cryotronics, Inc. • 575 McCorkle Boulevard • Westerville, OH 43082
Sales: (614) 891-2244 • Fax: (614) 891-1392 • sales@lakeshore.com • www.lakeshore.com