

CALIBRATION CERTIFICATE

Report Number: 1015401

Sensor Model: CX-1030-SD-HT-1.4L	Serial Number: X130217
Sensor Type: Cernox Resistor	Sales Order: 119941
Sensor Excitation: see <i>Test Data</i> page of report	Date: January 25, 2018
Temperature Range: 1.40 K to 325 K	Due: January 25, 2019

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.

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

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

Reported by: Derick Gillette
Calibration Engineer/Technician

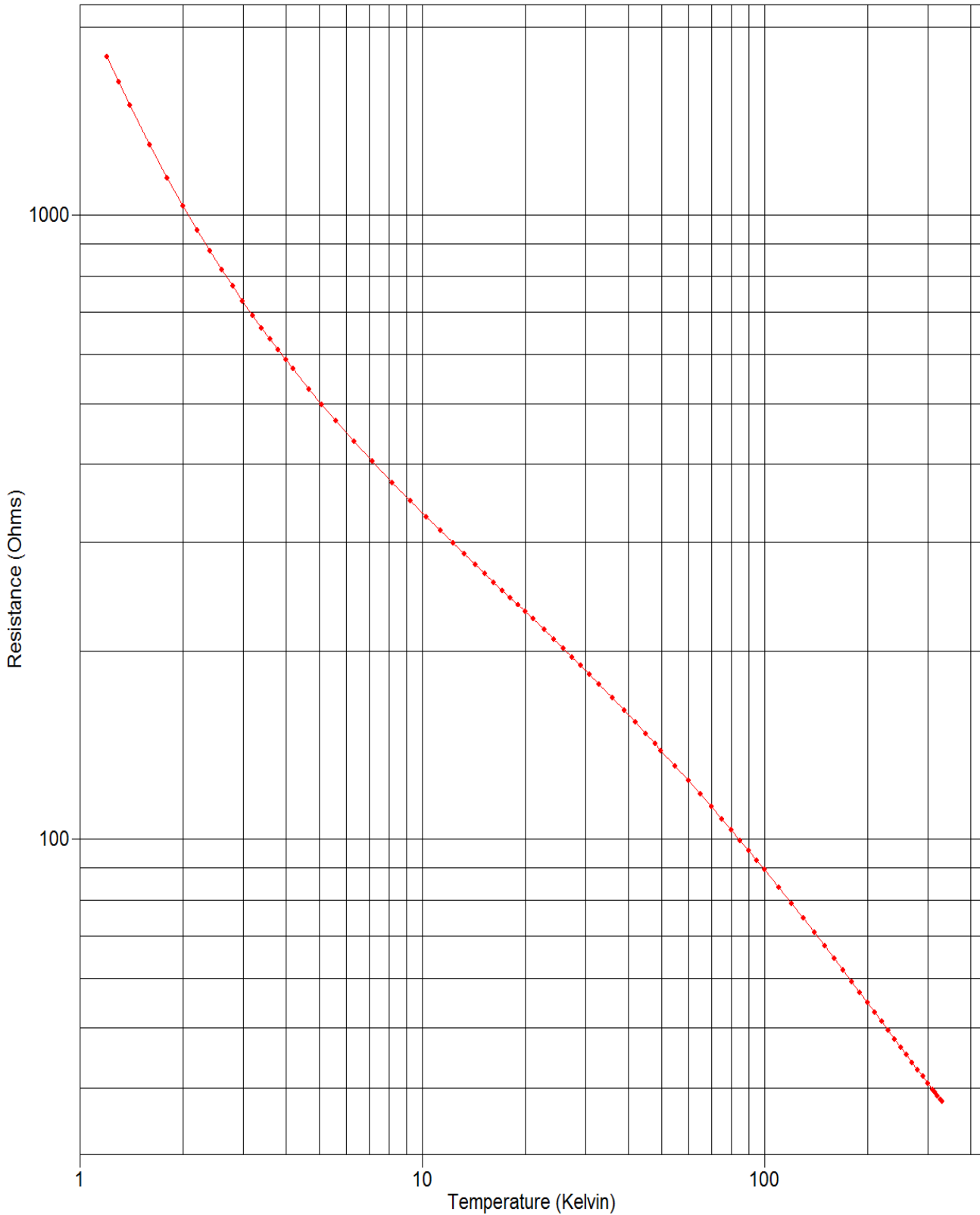
Approved by: John Krause
Metrology



DATA PLOT

Calibration Report: 1015401
Sensor Model: CX-1030-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 119941
Serial Number: X130217
Temperature Range: 1.40 K to 325 K



TEST DATA

Calibration Report: 1015401
Sensor Model: CX-1030-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 119941
Serial Number: X130217
Temperature Range: 1.40 K to 325 K

Index	Temp. (K)	Resistance (Ω)	Excitation	Index	Temp. (K)	Resistance (Ω)	Excitation
1	1.20193	1796.41	2mV \pm 25%	46	41.9558	153.893	2mV \pm 25%
2	1.29977	1634.42	2mV \pm 25%	47	44.9655	147.735	2mV \pm 25%
3	1.39993	1499.82	2mV \pm 25%	48	47.9637	142.163	2mV \pm 25%
4	1.59935	1295.33	2mV \pm 25%	49	49.9611	138.724	2mV \pm 25%
5	1.80015	1146.66	2mV \pm 25%	50	54.9572	130.933	2mV \pm 25%
6	2.00046	1034.84	2mV \pm 25%	51	59.9542	124.116	2mV \pm 25%
7	2.20061	947.280	2mV \pm 25%	52	64.9579	118.093	2mV \pm 25%
8	2.40121	876.472	2mV \pm 25%	53	69.9647	112.711	2mV \pm 25%
9	2.59898	818.866	2mV \pm 25%	54	74.9681	107.877	2mV \pm 25%
10	2.79985	769.723	2mV \pm 25%	55	79.9700	103.508	2mV \pm 25%
11	2.99582	728.886	2mV \pm 25%	56	84.9686	99.5209	2mV \pm 25%
12	3.20010	692.135	2mV \pm 25%	57	89.9694	95.8718	2mV \pm 25%
13	3.40062	660.772	2mV \pm 25%	58	94.9682	92.5146	2mV \pm 25%
14	3.59792	633.561	2mV \pm 25%	59	99.9642	89.4150	2mV \pm 25%
15	3.80003	608.797	2mV \pm 25%	60	109.983	83.8433	2mV \pm 25%
16	3.99963	586.930	2mV \pm 25%	61	119.989	78.9937	2mV \pm 25%
17	4.19558	567.490	2mV \pm 25%	62	129.985	74.7300	2mV \pm 25%
18	4.68400	526.518	2mV \pm 25%	63	140.002	70.9247	2mV \pm 25%
19	5.09206	498.221	2mV \pm 25%	64	150.008	67.5278	2mV \pm 25%
20	5.60959	468.254	2mV \pm 25%	65	160.017	64.4690	2mV \pm 25%
21	6.33219	434.405	2mV \pm 25%	66	170.023	61.6985	2mV \pm 25%
22	7.15594	403.727	2mV \pm 25%	67	180.033	59.1797	2mV \pm 25%
23	8.20039	373.182	2mV \pm 25%	68	190.040	56.8763	2mV \pm 25%
24	9.24432	348.904	2mV \pm 25%	69	200.050	54.7744	2mV \pm 25%
25	10.2787	329.195	2mV \pm 25%	70	210.051	52.8421	2mV \pm 25%
26	11.3064	312.698	2mV \pm 25%	71	220.055	51.0607	2mV \pm 25%
27	12.3166	298.776	2mV \pm 25%	72	230.069	49.4088	2mV \pm 25%
28	13.3092	286.804	2mV \pm 25%	73	240.074	47.8856	2mV \pm 25%
29	14.2910	276.295	2mV \pm 25%	74	250.074	46.4688	2mV \pm 25%
30	15.2652	266.932	2mV \pm 25%	75	260.071	45.1509	2mV \pm 25%
31	16.2295	258.549	2mV \pm 25%	76	270.092	43.9207	2mV \pm 25%
32	17.1912	250.908	2mV \pm 25%	77	280.101	42.7706	2mV \pm 25%
33	18.1481	243.916	2mV \pm 25%	78	290.099	41.6983	2mV \pm 25%
34	19.1078	237.406	2mV \pm 25%	79	300.124	40.6902	2mV \pm 25%
35	20.0715	231.366	2mV \pm 25%	80	310.125	39.7441	2mV \pm 25%
36	21.1370	225.135	2mV \pm 25%	81	315.132	39.2905	2mV \pm 25%
37	22.7157	216.700	2mV \pm 25%	82	320.138	38.8555	2mV \pm 25%
38	24.3095	208.972	2mV \pm 25%	83	326.168	38.3445	2mV \pm 25%
39	25.8829	202.039	2mV \pm 25%	84	330.145	38.0170	2mV \pm 25%
40	27.4660	195.615	2mV \pm 25%				
41	29.0644	189.638	2mV \pm 25%				
42	30.8586	183.441	2mV \pm 25%				
43	32.9563	176.800	2mV \pm 25%				
44	35.9555	168.266	2mV \pm 25%				
45	38.9575	160.686	2mV \pm 25%				



UNCERTAINTY ANALYSIS

Calibration Report: 1015401
 Sensor Model: CX-1030-SD-HT-1.4L
 Sensor Type: Cernox Resistor

Sales Order: 119941
 Serial Number: X130217
 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 (\pm mK)													
	GR	Cernox (CX)					RX			Platinum		RF-800	Diode	
		1010	1030	1050	1070	1080	102A	103A	202A	100 Ω	25 Ω	27 Ω		
1.4	4	4	4	4			4	4	4				5	7
4.2	4	4	4	4	4		4	6	5				5	5
10	4	5	5	4	4		10	15	12				7	6
20	8	10	9	8	8	8	35	35	28	9	10		13	9
30	9	13	11	9	9	9	76	61	46	9	9		14	31
50	11	18	14	12	12	11				10	10		13	37
100	20	29	22	17	16	14				11	12		12	32
300		78	60	46	45	36				24	24		25	35
400		124	94	74	72	60				45	45		45	49
500										51	51			54

Polynomial Fit Uncertainty

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

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

where

- σ_{fit} = standard deviation of the fit
- T_i = measured temperature for point i
- $T_{i,calc}$ = 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: 1015401
Sensor Model: CX-1030-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 119941
Serial Number: X130217
Temperature Range: 1.40 K to 325 K

Polynomial Type: Chebychev
Useful Range of Fit:

1.40 K to 14.3 K
1499 ohms to 276.3 ohms

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

ZL = 2.41254231235 ZU = 3.25440528066

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	5.759009	1.0415E-04	55295.52
1	-6.579686	1.6689E-04	-39424.79
2	2.722835	1.4654E-04	18580.76
3	-0.893052	1.5061E-04	-5929.69
4	0.232927	1.4374E-04	1620.51
5	-0.043254	1.3517E-04	-319.99
6	0.002371	1.3079E-04	18.13
7	0.002117	1.2971E-04	16.32
8	-0.001539	1.3067E-04	-11.78

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

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

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



POLYNOMIAL EQUATION

Calibration Report: 1015401
Sensor Model: CX-1030-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 119941
Serial Number: X130217
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	1796.409	1.20193	1.20173	0.21
2	1634.420	1.29977	1.30051	-0.74
3	1499.816	1.39993	1.39937	0.56
4	1295.327	1.59935	1.59881	0.54
5	1146.659	1.80015	1.80068	-0.53
6	1034.837	2.00046	2.00106	-0.59
7	947.2798	2.20061	2.20069	-0.08
8	876.4715	2.40121	2.40089	0.32
9	818.8660	2.59898	2.59850	0.48
10	769.7228	2.79985	2.79951	0.34
11	728.8856	2.99582	2.99556	0.27
12	692.1354	3.20010	3.20018	-0.09
13	660.7719	3.40062	3.40076	-0.13
14	633.5607	3.59792	3.59817	-0.25
15	608.7970	3.80003	3.80033	-0.31
16	586.9300	3.99963	3.99982	-0.18
17	567.4896	4.19558	4.19639	-0.81
18	526.5176	4.68400	4.68330	0.70
19	498.2214	5.09206	5.09198	0.08
20	468.2536	5.60959	5.60942	0.17
21	434.4050	6.33219	6.33159	0.60
22	403.7275	7.15594	7.15648	-0.54
23	373.1824	8.20039	8.20003	0.35
24	348.9037	9.24432	9.24474	-0.43
25	329.1952	10.27872	10.27868	0.04
26	312.6985	11.30644	11.30690	-0.45
27	298.7765	12.31663	12.31646	0.17
28	286.8042	13.30916	13.30881	0.34
29	276.2952	14.29100	14.29060	0.39
30	266.9316	15.26517	15.26566	-0.49
31	258.5487	16.22953	16.22948	0.06

Order of Fit = 8 RMS error of fit = 0.42 mK
Largest absolute error = -0.81 mK at data point no. 17



POLYNOMIAL EQUATION

Calibration Report: 1015401
Sensor Model: CX-1030-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 119941
Serial Number: X130217
Temperature Range: 1.40 K to 325 K

Polynomial Type: Chebychev
Useful Range of Fit:

14.3 K to 80.0 K
276.3 ohms to 103.5 ohms

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

ZL = 1.98169098822 ZU = 2.47534637283

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	43.277903	3.7119E-04	116591.68
1	-37.984589	6.0386E-04	-62902.84
2	7.781512	5.5354E-04	14057.72
3	-0.842935	5.2150E-04	-1616.37
4	0.090754	4.9719E-04	182.53
5	0.000888	4.6711E-04	1.90
6	-0.007890	4.7238E-04	-16.70

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

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

Temp. (K) = $\sum A_i * \text{COS}(i * \text{ARCCOS}(k))$, where $0 \leq i \leq 6$
and the A_i 's are the coefficients in the table above.



POLYNOMIAL EQUATION

Calibration Report: 1015401
Sensor Model: CX-1030-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 119941
Serial Number: X130217
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	298.7765	12.31646	12.31564	0.82
28	286.8042	13.30881	13.30967	-0.86
29	276.2952	14.29060	14.29152	-0.92
30	266.9316	15.26517	15.26604	-0.87
31	258.5487	16.22953	16.22892	0.62
32	250.9079	17.19116	17.18978	1.38
33	243.9160	18.14811	18.14600	2.11
34	237.4059	19.10783	19.10894	-1.11
35	231.3660	20.07149	20.07066	0.83
36	225.1355	21.13705	21.13780	-0.75
37	216.6996	22.71567	22.71643	-0.76
38	208.9722	24.30953	24.31285	-3.32
39	202.0394	25.88294	25.88222	0.72
40	195.6152	27.46597	27.46550	0.46
41	189.6384	29.06444	29.06209	2.34
42	183.4409	30.85863	30.85718	1.45
43	176.7997	32.95633	32.95667	-0.34
44	168.2663	35.95552	35.95874	-3.22
45	160.6856	38.95747	38.95788	-0.40
46	153.8934	41.95580	41.95483	0.97
47	147.7354	44.96552	44.96449	1.03
48	142.1628	47.96365	47.96319	0.46
49	138.7241	49.96111	49.96009	1.02
50	130.9333	54.95724	54.95774	-0.50
51	124.1161	59.95422	59.95753	-3.31
52	118.0932	64.95791	64.95566	2.25
53	112.7108	69.96473	69.96463	0.10
54	107.8769	74.96811	74.96977	-1.66
55	103.5076	79.96997	79.96672	3.26
56	99.52085	84.96858	84.97086	-2.28
57	95.87182	89.96939	89.96891	0.48

Order of Fit = 6 RMS error of fit = 1.62 mK
Largest absolute error = -3.32 mK at data point no. 38



POLYNOMIAL EQUATION

Calibration Report: 1015401
Sensor Model: CX-1030-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 119941
Serial Number: X130217
Temperature Range: 1.40 K to 325 K

Polynomial Type: Chebychev
Useful Range of Fit:

80.0 K to 325 K
103.5 ohms to 38.44 ohms

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

ZL = 1.57997772235 ZU = 2.05196572362

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	177.747154	1.6388E-03	108464.01
1	-126.935766	2.5270E-03	-50231.96
2	21.684351	2.4318E-03	8916.90
3	-3.038389	2.3167E-03	-1311.50
4	0.610131	2.2054E-03	276.65
5	-0.113027	2.2076E-03	-51.20
6	0.014157	2.1854E-03	6.48
7	-0.005399	2.1106E-03	-2.56

Z = Log(Resistance)

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

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



POLYNOMIAL EQUATION

Calibration Report: 1015401
Sensor Model: CX-1030-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 119941
Serial Number: X130217
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	112.7108	69.96463	69.96321	1.42
54	107.8769	74.96977	74.97253	-2.76
55	103.5076	79.96672	79.96691	-0.19
56	99.52085	84.96858	84.96857	0.01
57	95.87182	89.96939	89.96798	1.41
58	92.51459	94.96821	94.96709	1.12
59	89.41497	99.96424	99.96144	2.80
60	83.84329	109.98267	109.98547	-2.80
61	78.99375	119.98866	119.99419	-5.53
62	74.72996	129.98520	129.97977	5.43
63	70.92466	140.00247	140.00705	-4.58
64	67.52780	150.00769	150.00837	-0.68
65	64.46897	160.01687	160.00982	7.04
66	61.69850	170.02316	170.01868	4.48
67	59.17966	180.03323	180.02850	4.73
68	56.87629	190.03993	190.05850	-18.57
69	54.77439	200.04995	200.05122	-1.26
70	52.84210	210.05101	210.04715	3.86
71	51.06067	220.05464	220.04569	8.95
72	49.40883	230.06886	230.07935	-10.48
73	47.88563	240.07446	240.06734	7.12
74	46.46881	250.07437	250.07242	1.95
75	45.15087	260.07117	260.07435	-3.18
76	43.92072	270.09186	270.08756	4.30
77	42.77057	280.10074	280.11085	-10.10
78	41.69829	290.09860	290.09690	1.70
79	40.69020	300.12430	300.11245	11.85
80	39.74409	310.12462	310.12494	-0.32
81	39.29048	315.13235	315.15432	-21.96
82	38.85551	320.13755	320.12590	11.66
83	38.34454	326.16840	326.16207	6.34
84	38.01699	330.14462	330.14837	-3.75

Order of Fit = 7 RMS error of fit = 7.40 mK
Largest absolute error = -21.96 mK at data point no. 81



INTERPOLATION TABLE

Calibration Report: 1015401

Sensor Model: CX-1030-SD-HT-1.4L

Sensor Type: Cernox Resistor

Sales Order: 119941

Serial Number: X130217

Temperature Range: 1.40 K to 325 K

<u>Temp (K)</u>	<u>Res. (Ω)</u>	<u>dR/dT (Ω/K)</u>	<u>dlogR/dlogT</u>	<u>Temp (K)</u>	<u>Res. (Ω)</u>	<u>dR/dT (Ω/K)</u>	<u>dlogR/dlogT</u>
1.400	1499.03	-1231.2	-1.1498	15.50	264.821	-8.9161	-0.52186
1.500	1387.30	-1014.2	-1.0965	16.00	260.471	-8.4895	-0.52149
1.600	1294.31	-853.99	-1.0557	16.50	256.325	-8.1008	-0.52146
1.700	1215.25	-731.95	-1.0239	17.00	252.365	-7.7431	-0.52159
1.800	1147.09	-634.87	-0.99623	17.50	248.577	-7.4133	-0.52190
1.900	1087.65	-556.40	-0.97196	18.00	244.948	-7.1085	-0.52237
2.000	1035.36	-491.65	-0.94973	18.50	241.465	-6.8264	-0.52301
2.100	988.966	-437.64	-0.92930	19.00	238.118	-6.5641	-0.52376
2.200	947.550	-391.96	-0.91004	19.50	234.898	-6.3200	-0.52465
2.300	910.349	-353.05	-0.89198	20.00	231.795	-6.0920	-0.52563
2.400	876.756	-319.65	-0.87500	21.00	225.914	-5.6789	-0.52789
2.500	846.267	-290.81	-0.85911	22.00	220.421	-5.3144	-0.53042
2.600	818.468	-265.75	-0.84418	23.00	215.272	-4.9904	-0.53318
2.700	793.012	-243.84	-0.83021	24.00	210.429	-4.7002	-0.53607
2.800	769.612	-224.59	-0.81710	25.00	205.862	-4.4391	-0.53909
2.900	748.019	-207.60	-0.80483	26.00	201.543	-4.2027	-0.54216
3.000	728.029	-192.52	-0.79331	27.00	197.449	-3.9875	-0.54526
3.100	709.461	-179.08	-0.78248	28.00	193.562	-3.7909	-0.54838
3.200	692.166	-167.05	-0.77229	29.00	189.862	-3.6105	-0.55147
3.300	676.011	-156.24	-0.76270	30.00	186.336	-3.4443	-0.55454
3.400	660.883	-146.49	-0.75363	31.00	182.969	-3.2908	-0.55756
3.500	646.682	-137.66	-0.74506	32.00	179.751	-3.1486	-0.56052
3.600	633.324	-129.64	-0.73693	33.00	176.669	-3.0164	-0.56344
3.700	620.730	-122.34	-0.72921	34.00	173.715	-2.8933	-0.56628
3.800	608.835	-115.66	-0.72188	35.00	170.880	-2.7781	-0.56902
3.900	597.580	-109.54	-0.71489	36.00	168.156	-2.6705	-0.57172
4.000	586.911	-103.91	-0.70821	37.00	165.536	-2.5696	-0.57436
4.200	567.150	-93.963	-0.69584	38.00	163.015	-2.4748	-0.57689
4.400	549.232	-85.428	-0.68438	39.00	160.585	-2.3856	-0.57936
4.600	532.903	-78.044	-0.67367	40.00	158.242	-2.3015	-0.58177
4.800	517.947	-71.658	-0.66408	42.00	153.796	-2.1471	-0.58634
5.000	504.188	-66.051	-0.65503	44.00	149.643	-2.0088	-0.59064
5.200	491.481	-61.121	-0.64668	46.00	145.752	-1.8844	-0.59471
5.400	479.703	-56.743	-0.63875	48.00	142.098	-1.7719	-0.59853
5.600	468.751	-52.859	-0.63148	50.00	138.657	-1.6699	-0.60217
5.800	458.532	-49.389	-0.62473	52.00	135.412	-1.5770	-0.60559
6.000	448.972	-46.258	-0.61818	54.00	132.344	-1.4921	-0.60883
6.500	427.547	-39.723	-0.60391	56.00	129.438	-1.4146	-0.61199
7.000	409.026	-34.559	-0.59144	58.00	126.682	-1.3432	-0.61498
7.500	392.813	-30.431	-0.58103	60.00	124.062	-1.2776	-0.61789
8.000	378.473	-27.042	-0.57161	65.00	118.043	-1.1346	-0.62476
8.500	365.668	-24.259	-0.56390	70.00	112.675	-1.0162	-0.63132
9.000	354.142	-21.914	-0.55691	75.00	107.849	-0.91687	-0.63760
9.500	343.693	-19.937	-0.55107	77.35	105.744	-0.87571	-0.64057
10.00	334.159	-18.239	-0.54582	80.00	103.480	-0.83325	-0.64418
10.50	325.413	-16.780	-0.54144	85.00	99.4969	-0.76153	-0.65057
11.00	317.349	-15.507	-0.53752	90.00	95.8494	-0.69899	-0.65634
11.50	309.879	-14.395	-0.53423	95.00	92.4934	-0.64464	-0.66211
12.00	302.932	-13.415	-0.53139	100.0	89.3919	-0.59697	-0.66781
12.50	296.445	-12.548	-0.52911	105.0	86.5145	-0.55484	-0.67339
13.00	290.369	-11.769	-0.52690	110.0	83.8358	-0.51739	-0.67886
13.50	284.664	-11.066	-0.52478	115.0	81.3340	-0.48391	-0.68421
14.00	279.290	-10.441	-0.52338	120.0	78.9911	-0.45377	-0.68935
14.50	274.210	-9.8892	-0.52293	125.0	76.7915	-0.42651	-0.69427
15.00	269.394	-9.3832	-0.52246	130.0	74.7218	-0.40175	-0.69895



INTERPOLATION TABLE

Calibration Report: 1015401

Sensor Model: CX-1030-SD-HT-1.4L

Sensor Type: Cernox Resistor

Sales Order: 119941

Serial Number: X130217

Temperature Range: 1.40 K to 325 K

<u>Temp (K)</u>	<u>Res. (Ω)</u>	<u>dR/dT (Ω/K)</u>	<u>dlogR/dlogT</u>	<u>Temp (K)</u>	<u>Res. (Ω)</u>	<u>dR/dT (Ω/K)</u>	<u>dlogR/dlogT</u>
135.0	72.7704	-0.37915	-0.70338	235.0	48.6441	-0.15254	-0.73691
140.0	70.9272	-0.35845	-0.70752	240.0	47.8955	-0.14695	-0.73633
145.0	69.1832	-0.33942	-0.71139	245.0	47.1742	-0.14164	-0.73560
150.0	67.5305	-0.32188	-0.71497	250.0	46.4787	-0.13659	-0.73472
155.0	65.9621	-0.30567	-0.71827	255.0	45.8078	-0.13180	-0.73369
160.0	64.4718	-0.29064	-0.72128	260.0	45.1603	-0.12723	-0.73252
165.0	63.0539	-0.27668	-0.72402	265.0	44.5351	-0.12289	-0.73122
170.0	61.7034	-0.26368	-0.72648	270.0	43.9311	-0.11874	-0.72980
175.0	60.4157	-0.25156	-0.72867	273.15	43.5610	-0.11623	-0.72885
180.0	59.1865	-0.24023	-0.73060	275.0	43.3473	-0.11479	-0.72826
185.0	58.0121	-0.22963	-0.73228	280.0	42.7829	-0.11102	-0.72662
190.0	56.8891	-0.21968	-0.73371	285.0	42.2368	-0.10742	-0.72486
195.0	55.8143	-0.21035	-0.73490	290.0	41.7084	-0.10398	-0.72301
200.0	54.7847	-0.20157	-0.73587	295.0	41.1967	-0.10070	-0.72106
205.0	53.7977	-0.19331	-0.73661	300.0	40.7012	-9.7551e-2	-0.71903
210.0	52.8508	-0.18552	-0.73715	305.0	40.2210	-9.4541e-2	-0.71692
215.0	51.9418	-0.17817	-0.73748	310.0	39.7555	-9.1659e-2	-0.71473
220.0	51.0685	-0.17122	-0.73761	315.0	39.3042	-8.8898e-2	-0.71247
225.0	50.2290	-0.16465	-0.73755	320.0	38.8664	-8.6252e-2	-0.71014
230.0	49.4214	-0.15843	-0.73732	325.0	38.4415	-8.3715e-2	-0.70776



THERMAL CYCLE TESTING

Calibration Report: 1015401
Sensor Model: CX-1030-SD-HT-1.4L
Sensor Type: Cernox Resistor

Sales Order: 119941
Serial Number: X130217

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:	41.3 Ω
Liquid Nitrogen:	106 Ω
Liquid Helium:	566 Ω

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

Recommended Operating Parameters:

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



BREAKPOINTS CUBIC SPLINE FORMAT

Calibration Report: 1015401

Sensor Model: CX-1030-SD-HT-1.4L

Sensor Type: Cernox Resistor

Sales Order: 119941

Serial Number: X130217

Temperature Range: 1.40 K to 325 K

Sensor Model: CX-1030-SD-HT-1.4L
Serial Number: X130217
Data Format: 7 (Ohms/Kelvin)
Setpoint Limit: 325

Measurement (ohms)	Temp (K)	Curvature	Measurement (ohms)	Temp (K)	Curvature
3.80170E+01	3.30148E+02	8.87559E-01	2.76295E+02	1.42906E+01	1.09373E-03
3.83445E+01	3.26162E+02	8.56514E-01	2.86804E+02	1.33088E+01	9.36139E-04
3.88555E+01	3.20126E+02	8.08084E-01	2.98776E+02	1.23165E+01	8.04537E-04
3.92905E+01	3.15154E+02	7.70439E-01	3.12698E+02	1.13069E+01	6.72186E-04
3.97441E+01	3.10125E+02	7.32781E-01	3.29195E+02	1.02787E+01	5.47171E-04
4.06902E+01	3.00112E+02	6.62689E-01	3.48904E+02	9.24474E+00	4.31019E-04
4.16983E+01	2.90097E+02	5.97972E-01	3.73182E+02	8.20003E+00	3.24842E-04
4.27706E+01	2.80111E+02	5.38224E-01	4.03727E+02	7.15648E+00	2.32750E-04
4.39207E+01	2.70088E+02	4.82934E-01	4.34405E+02	6.33159E+00	1.70458E-04
4.51509E+01	2.60074E+02	4.32139E-01	4.68254E+02	5.60942E+00	1.23678E-04
4.64688E+01	2.50072E+02	3.85596E-01	4.98221E+02	5.09198E+00	9.53409E-05
4.78856E+01	2.40067E+02	3.43003E-01	5.26518E+02	4.68330E+00	7.51420E-05
4.94088E+01	2.30079E+02	3.04198E-01	5.67490E+02	4.19639E+00	5.47926E-05
5.10607E+01	2.20046E+02	2.68724E-01	5.86930E+02	3.99982E+00	4.80504E-05
5.28421E+01	2.10047E+02	2.36645E-01	6.08797E+02	3.80033E+00	4.11593E-05
5.47744E+01	2.00051E+02	2.07610E-01	6.33561E+02	3.59817E+00	3.49439E-05
5.68763E+01	1.90058E+02	1.81405E-01	6.60772E+02	3.40076E+00	2.94033E-05
5.91797E+01	1.80028E+02	1.57736E-01	6.92135E+02	3.20018E+00	2.43340E-05
6.16985E+01	1.70019E+02	1.36553E-01	7.28886E+02	2.99556E+00	1.97355E-05
6.44690E+01	1.60010E+02	1.17621E-01	7.69723E+02	2.79951E+00	1.58415E-05
6.75278E+01	1.50008E+02	1.00778E-01	8.18866E+02	2.59850E+00	1.23535E-05
7.09247E+01	1.40007E+02	8.58416E-02	8.76472E+02	2.40089E+00	9.41228E-06
7.47300E+01	1.29980E+02	7.26190E-02	9.47280E+02	2.20069E+00	6.91155E-06
7.89937E+01	1.19994E+02	6.10382E-02	1.03484E+03	2.00106E+00	4.89398E-06
8.38433E+01	1.09985E+02	5.08150E-02	1.14666E+03	1.80068E+00	3.32874E-06
8.94150E+01	9.99614E+01	4.18828E-02	1.29533E+03	1.59881E+00	2.17095E-06
9.25146E+01	9.49671E+01	3.79039E-02	1.49982E+03	1.39937E+00	1.30446E-06
9.58718E+01	8.99680E+01	3.39638E-02	1.63442E+03	1.30051E+00	8.69659E-07
9.95209E+01	8.49686E+01	3.03507E-02	1.79641E+03	1.20173E+00	3.46397E-07
1.03508E+02	7.99667E+01	2.64143E-02			
1.07877E+02	7.49698E+01	2.36302E-02			
1.12711E+02	6.99646E+01	2.05159E-02			
1.18093E+02	6.49557E+01	1.76948E-02			
1.24116E+02	5.99575E+01	1.50419E-02			
1.30933E+02	5.49577E+01	1.25967E-02			
1.38724E+02	4.99601E+01	1.03939E-02			
1.42163E+02	4.79632E+01	9.59555E-03			
1.47735E+02	4.49645E+01	8.42007E-03			
1.53893E+02	4.19548E+01	7.34045E-03			
1.60686E+02	3.89579E+01	6.34890E-03			
1.68266E+02	3.59587E+01	5.44183E-03			
1.76800E+02	3.29567E+01	4.62366E-03			
1.83441E+02	3.08572E+01	4.10372E-03			
1.89638E+02	2.90621E+01	3.68466E-03			
1.95615E+02	2.74655E+01	3.33508E-03			
2.02039E+02	2.58822E+01	3.00767E-03			
2.08972E+02	2.43128E+01	2.70195E-03			
2.16700E+02	2.27164E+01	2.40826E-03			
2.25135E+02	2.11378E+01	2.13514E-03			
2.31366E+02	2.00707E+01	1.95935E-03			
2.37406E+02	1.91089E+01	1.80399E-03			
2.43916E+02	1.81460E+01	1.65356E-03			
2.50908E+02	1.71898E+01	1.50451E-03			
2.58549E+02	1.62289E+01	1.36809E-03			
2.66932E+02	1.52660E+01	1.19510E-03			



BREAKPOINTS 340 FORMAT

Calibration Report: 1015401

Sensor Model: CX-1030-SD-HT-1.4L

Sensor Type: Cernox Resistor

Sales Order: 119941

Serial Number: X130217

Temperature Range: 1.40 K to 325 K

Name: CX-1030-SD-HT-1.4L
Serial Number: X130217
Format: 4 ;Log Ohms/Kelvin
Limit: 325.0
Coefficient: 1 ;Negative

Point 1: 1.58479,325.000	Point 51: 1.98476, 89.000	Point 101: 2.47469, 12.350
Point 2: 1.59053,319.000	Point 52: 1.99285, 86.500	Point 102: 2.48422, 11.850
Point 3: 1.59591,313.500	Point 53: 2.00114, 84.000	Point 103: 2.49420, 11.350
Point 4: 1.60140,308.000	Point 54: 2.00964, 81.500	Point 104: 2.50470, 10.850
Point 5: 1.60701,302.500	Point 55: 2.01836, 79.000	Point 105: 2.51465, 10.400
Point 6: 1.61274,297.000	Point 56: 2.02731, 76.500	Point 106: 2.52510, 9.950
Point 7: 1.61859,291.500	Point 57: 2.03651, 74.000	Point 107: 2.53612, 9.500
Point 8: 1.62458,286.000	Point 58: 2.04599, 71.500	Point 108: 2.54779, 9.050
Point 9: 1.63070,280.500	Point 59: 2.05378, 69.500	Point 109: 2.55877, 8.650
Point 10: 1.63695,275.000	Point 60: 2.06176, 67.500	Point 110: 2.57037, 8.250
Point 11: 1.64335,269.500	Point 61: 2.06995, 65.500	Point 111: 2.58269, 7.850
Point 12: 1.64989,264.000	Point 62: 2.07835, 63.500	Point 112: 2.59581, 7.450
Point 13: 1.65659,258.500	Point 63: 2.08699, 61.500	Point 113: 2.60807, 7.100
Point 14: 1.66344,253.000	Point 64: 2.09632, 59.400	Point 114: 2.62107, 6.750
Point 15: 1.67045,247.500	Point 65: 2.10547, 57.400	Point 115: 2.63499, 6.400
Point 16: 1.67763,242.000	Point 66: 2.11490, 55.400	Point 116: 2.64991, 6.050
Point 17: 1.68498,236.500	Point 67: 2.12463, 53.400	Point 117: 2.66506, 5.720
Point 18: 1.69182,231.500	Point 68: 2.13468, 51.400	Point 118: 2.68088, 5.400
Point 19: 1.69881,226.500	Point 69: 2.14402, 49.600	Point 119: 2.69688, 5.100
Point 20: 1.70596,221.500	Point 70: 2.15365, 47.800	Point 120: 2.71417, 4.800
Point 21: 1.71328,216.500	Point 71: 2.16359, 46.000	Point 121: 2.73169, 4.520
Point 22: 1.72076,211.500	Point 72: 2.17387, 44.200	Point 122: 2.75070, 4.240
Point 23: 1.72842,206.500	Point 73: 2.18450, 42.400	Point 123: 2.76997, 4.020
Point 24: 1.73626,201.500	Point 74: 2.19552, 40.600	Point 124: 2.78115, 3.840
Point 25: 1.74428,196.500	Point 75: 2.20632, 38.900	Point 125: 2.79627, 3.660
Point 26: 1.75251,191.500	Point 76: 2.21685, 37.300	Point 126: 2.81245, 3.480
Point 27: 1.76093,186.500	Point 77: 2.22776, 35.700	Point 127: 2.82886, 3.310
Point 28: 1.76957,181.500	Point 78: 2.23908, 34.100	Point 128: 2.84542, 3.150
Point 29: 1.77843,176.500	Point 79: 2.25011, 32.600	Point 129: 2.86319, 2.990
Point 30: 1.78752,171.500	Point 80: 2.26156, 31.100	Point 130: 2.88238, 2.830
Point 31: 1.79685,166.500	Point 81: 2.27349, 29.600	Point 131: 2.90185, 2.680
Point 32: 1.80546,162.000	Point 82: 2.28509, 28.200	Point 132: 2.92292, 2.530
Point 33: 1.81428,157.500	Point 83: 2.29717, 26.800	Point 133: 2.94433, 2.390
Point 34: 1.82333,153.000	Point 84: 2.30981, 25.400	Point 134: 2.96760, 2.250
Point 35: 1.83260,148.500	Point 85: 2.32210, 24.100	Point 135: 2.99308, 2.110
Point 36: 1.84212,144.000	Point 86: 2.33396, 22.900	Point 136: 3.01906, 1.980
Point 37: 1.85189,139.500	Point 87: 2.34637, 21.700	Point 137: 3.04533, 1.860
Point 38: 1.86193,135.000	Point 88: 2.35941, 20.500	Point 138: 3.07415, 1.740
Point 39: 1.87226,130.500	Point 89: 2.36911, 19.650	Point 139: 3.10608, 1.620
Point 40: 1.88289,126.000	Point 90: 2.37737, 18.950	Point 140: 3.13874, 1.510
Point 41: 1.89261,122.000	Point 91: 2.38592, 18.250	Point 141: 3.17197, 1.410
Point 42: 1.90258,118.000	Point 92: 2.39415, 17.600	Point 142: 3.17581, 1.400
Point 43: 1.91284,114.000	Point 93: 2.40267, 16.950	
Point 44: 1.92341,110.000	Point 94: 2.41153, 16.300	
Point 45: 1.93429,106.000	Point 95: 2.42002, 15.700	
Point 46: 1.94552,102.000	Point 96: 2.42885, 15.100	
Point 47: 1.95420, 99.000	Point 97: 2.43805, 14.500	
Point 48: 1.96159, 96.500	Point 98: 2.44684, 13.950	
Point 49: 1.96914, 94.000	Point 99: 2.45600, 13.400	
Point 50: 1.97686, 91.500	Point 100: 2.46557, 12.850	



BREAKPOINTS 91C/93C/330 FORMAT

Calibration Report: 1015401

Sensor Model: CX-1030-SD-HT-1.4L

Sensor Type: Cernox Resistor

Sales Order: 119941

Serial Number: X130217

Temperature Range: 1.40 K to 325 K

Interpolation Method: Lagrangian

Limit: 325.0 (Kelvin)

Format: 4 (Log Ohms/Kelvin)

Number of Breakpoints: 51

No.	Units	Temperature (K)	No.	Units	Temperature (K)
1	1.58480	325.0	31	2.49527	11.3
2	1.58575	324.0	32	2.53367	9.6
3	1.60040	309.0	33	2.56893	8.3
4	1.61593	294.0	34	2.60454	7.2
5	1.63240	279.0	35	2.63922	6.3
6	1.64990	264.0	36	2.67590	5.5
7	1.66853	249.0	37	2.71429	4.8
8	1.68840	234.0	38	2.74662	4.3
9	1.70961	219.0	39	2.78450	3.8
10	1.73233	204.0	40	2.82012	3.4
11	1.75671	189.0	41	2.85093	3.1
12	1.78296	174.0	42	2.88627	2.8
13	1.81133	159.0	43	2.91300	2.6
14	1.84214	144.0	44	2.94288	2.4
15	1.87579	129.0	45	2.97660	2.2
16	1.91287	114.0	46	3.01509	2.0
17	1.95421	99.0	47	3.03649	1.9
18	2.00115	84.0	48	3.05960	1.8
19	2.05577	69.0	49	3.08466	1.7
20	2.09588	59.5	50	3.14217	1.5
21	2.14194	50.0	51	3.17581	1.4
22	2.16928	45.0			
23	2.19932	40.0			
24	2.23269	35.0			
25	2.27030	30.0			
26	2.30893	25.5			
27	2.34641	21.7			
28	2.38408	18.4			
29	2.42149	15.6			
30	2.45946	13.2			

Temperature for Resistance Decades:

Res. (Ohms)	Temp. (K)
100	84.343
1000	2.075



BREAKPOINTS 234 FORMAT

Calibration Report: 1015401

Sensor Model: CX-1030-SD-HT-1.4L

Sensor Type: Cernox Resistor

Sales Order: 119941

Serial Number: X130217

Temperature Range: 1.40 K to 325 K

Maximum Temperature Error:

1.4 - 10 K:	0.006 K
10 - 20 K:	0.010 K
20 - 40 K:	0.016 K
40 - 100 K:	0.029 K
> 100 K:	0.109 K

BP #	Temp. (K)	Res. (W)	Log10 Res.	BP #	Temp. (K)	Res. (W)	Log10 Res.
1	309.399	39.81072	1.600	41	17.153	251.1886	2.400
2	290.206	41.68694	1.620	42	15.703	263.0268	2.420
3	272.373	43.65158	1.640	43	14.378	275.4229	2.440
4	255.753	45.70882	1.660	44	13.169	288.4032	2.460
5	240.221	47.86301	1.680	45	12.070	301.9952	2.480
6	225.671	50.11872	1.700	46	11.073	316.2278	2.500
7	212.011	52.48075	1.720	47	10.168	331.1311	2.520
8	199.163	54.95409	1.740	48	9.349	346.7369	2.540
9	187.058	57.54399	1.760	49	8.608	363.0781	2.560
10	175.637	60.25596	1.780	50	7.937	380.1894	2.580
11	164.849	63.09573	1.800	51	7.330	398.1072	2.600
12	154.650	66.06934	1.820	52	6.780	416.8694	2.620
13	145.000	69.18310	1.840	53	6.281	436.5158	2.640
14	135.866	72.44360	1.860	54	5.829	457.0882	2.660
15	127.219	75.85776	1.880	55	5.419	478.6301	2.680
16	119.033	79.43282	1.900	56	5.046	501.1872	2.700
17	111.286	83.17638	1.920	57	4.706	524.8075	2.720
18	103.959	87.09636	1.940	58	4.396	549.5409	2.740
19	97.037	91.20108	1.960	59	4.114	575.4399	2.760
20	90.503	95.49926	1.980	60	3.855	602.5596	2.780
21	84.343	100.0000	2.000	61	3.618	630.9573	2.800
22	78.540	104.7129	2.020	62	3.401	660.6934	2.820
23	73.076	109.6478	2.040	63	3.202	691.8310	2.840
24	67.940	114.8154	2.060	64	3.019	724.4360	2.860
25	63.117	120.2264	2.080	65	2.850	758.5776	2.880
26	58.592	125.8925	2.100	66	2.695	794.3282	2.900
27	54.349	131.8257	2.120	67	2.551	831.7638	2.920
28	50.373	138.0384	2.140	68	2.418	870.9636	2.940
29	46.648	144.5440	2.160	69	2.295	912.0108	2.960
30	43.159	151.3561	2.180	70	2.181	954.9926	2.980
31	39.893	158.4893	2.200	71	2.075	1000.000	3.000
32	36.836	165.9587	2.220	72	1.884	1096.478	3.040
33	33.977	173.7801	2.240	73	1.718	1202.264	3.080
34	31.306	181.9701	2.260	74	1.573	1318.257	3.120
35	28.811	190.5461	2.280	75	1.446	1445.440	3.160
36	26.486	199.5262	2.300	76	1.335	1584.893	3.200
37	24.322	208.9296	2.320	77	1.236	1737.801	3.240
38	22.313	218.7762	2.340				
39	20.452	229.0868	2.360				
40	18.734	239.8833	2.380				

