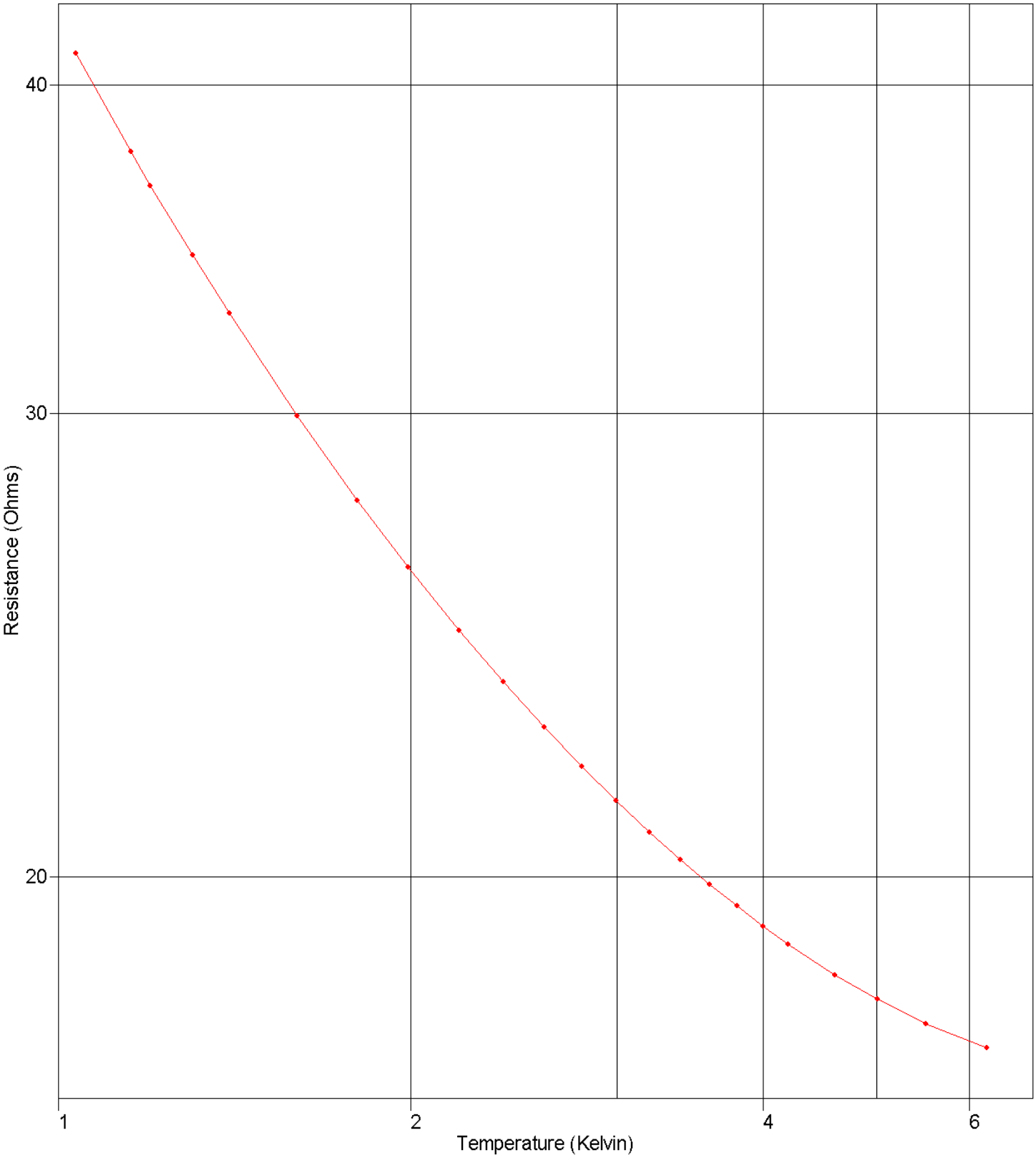
DATA PLOT

Calibration Report: 505707
Sensor Model: GR-200A-30-CD-1.15A
Sensor Type: Germanium Resistor

Sales Order: 35105
Serial Number: 29931
Temperature Range: 1.20K to 5.00K



LakeShore
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F010-04-00 (08/06/04)

TEST DATA

Calibration Report: 505707 Sales Order: 35105
Sensor Model: GR-200A-30-CD-1.15A Serial Number: 29931
Sensor Type: Germanium Resistor Temperature Range: 1.20K to 5.00K

Index	Temp. (K)	Resistance (Ω)	Excitation	Index	Temp. (K)	Resistance (Ω)	Excitation
1	1.03662	41.1302	2mV±25%	16	3.59990	19.8682	2mV±25%
2	1.15453	37.7360	2mV±25%	17	3.80036	19.4883	2mV±25%
3	1.19979	36.6274	2mV±25%	18	4.00046	19.1536	2mV±25%
4	1.30372	34.4621	2mV±25%	19	4.20284	18.8546	2mV±25%
5	1.40101	32.7510	2mV±25%	20	4.60777	18.3541	2mV±25%
6	1.60101	29.9398	2mV±25%	21	5.00907	17.9618	2mV±25%
7	1.80291	27.7886	2mV±25%	22	5.51054	17.5843	2mV±25%
8	1.99203	26.2128	2mV±25%	23	6.21243	17.2124	2mV±25%
9	2.20130	24.8079	2mV±25%				
10	2.40120	23.7110	2mV±25%				
11	2.60177	22.7917	2mV±25%				
12	2.80233	22.0171	2mV±25%				
13	2.99817	21.3696	2mV±25%				
14	3.20049	20.7937	2mV±25%				
15	3.39853	20.3038	2mV±25%				

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Calibration Data Uncertainty

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

T (K)	Uncertainty (+/- mK)											
	Ge (GR-200-X)		Cernox (CX-Y)		CGR	RX		Pt		RhFe		Diode
	X ≤ 100	X ≥ 250	Y ≤ 1030	Y ≥ 1050		-102	-103	100 Ω	25 Ω	27 Ω	100 Ω	
1.4	4	4	4	4	4	4	4			4	4	7
4.2	4	4	4	4	4	4	6			4	4	5
10	4	4	5	4	4	10	15			4	5	6
20	8	7	9	8	8	34	34	8	10	8	9	9
30	9	8	11	9	9	72	60	8	8	9	9	28
50	12	11	16	12	13			10	10	10	10	34
100	32	18	24	16	27			11	11	11	11	30
300			72	40	100			22	22	22	22	33
400			120	67				43	43	42		47
500								48	48			52

Polynomial Fit Uncertainty

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

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

where σ_{fit} = standard deviation of the fit
T_i = measured temperature for point i
T_{icalc} = the temperature calculated from the polynomial equation for point i
N = number of data points in fit range
n = number of fit coefficients
ΔT_{RMS} = root mean square deviation of fit

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

POLYNOMIAL EQUATION

Calibration Report: 505707 Sales Order: 35105
Sensor Model: GR-200A-30-CD-1.15A Serial Number: 29931
Sensor Type: Germanium Resistor Temperature Range: 1.20K to 5.00K

Polynomial Type: Chebychev
Useful Range of Fit:

1.20K	to	5.00K
36.60 Ohms	to	17.97 Ohms

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

ZL = 1.23584045757 ZU = 1.6141608407

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	2.627296	1.2273E-03	2140.69
1	-2.160566	2.3127E-03	-934.21
2	0.802884	1.8806E-03	426.94
3	-0.317102	1.3266E-03	-239.03
4	0.145553	6.4113E-04	227.03
5	-0.072347	5.8796E-04	-123.05
6	0.036971	1.0473E-03	35.30
7	-0.023721	1.3571E-03	-17.48
8	0.009539	1.4527E-03	6.57
9	-0.009758	1.3759E-03	-7.09
10	0.001887	1.1127E-03	1.70
11	-0.004032	8.2197E-04	-4.90

Z = Log(resistance)

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

Temp. (K) = ΣA_i* COS(i * ARCCOS(X)), where 0 <= i <= 11
and the A_i's are the coefficients in the table above.

POLYNOMIAL EQUATION

Calibration Report: 505707 Sales Order: 35105
Sensor Model: GR-200A-30-CD-1.15A Serial Number: 29931
Sensor Type: Germanium Resistor Temperature Range: 1.20K to 5.00K

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

	R Meas. (Ω)	T Meas. (K)	T Eq. (K)	T diff. (mK)
1	41.13020	1.03662	1.03661	0.01
2	37.73597	1.15453	1.15494	-0.41
3	36.62743	1.19979	1.19892	0.88
4	34.46211	1.30372	1.30476	-1.04
5	32.75100	1.40101	1.40041	0.60
6	29.93979	1.60101	1.60053	0.49
7	27.78860	1.80291	1.80428	-1.36
8	26.21283	1.99203	1.99140	0.63
9	24.80787	2.20130	2.20016	1.13
10	23.71099	2.40120	2.40140	-0.19
11	22.79167	2.60177	2.60311	-1.34
12	22.01705	2.80233	2.80298	-0.65
13	21.36960	2.99817	2.99774	0.43
14	20.79371	3.20049	3.19914	1.35
15	20.30383	3.39853	3.39747	1.05
16	19.86821	3.59990	3.60004	-0.14
17	19.48832	3.80036	3.80134	-0.99
18	19.15364	4.00046	4.00189	-1.43
19	18.85461	4.20284	4.20366	-0.82
20	18.35413	4.60777	4.60602	1.75
21	17.96176	5.00907	5.00702	2.05
22	17.58427	5.51054	5.51331	-2.77
23	17.21236	6.21243	6.21165	0.77

Order of Fit = 11 RMS error of fit = 1.16 mK
Largest absolute error = -2.77 mK at data point no. 22

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INTERPOLATION TABLE

Calibration Report: 505707 Sales Order: 35105
Sensor Model: GR-200A-30-CD-1.15A Serial Number: 29931
Sensor Type: Germanium Resistor Temperature Range: 1.20K to 5.00K

Temp (K)	Res. (Ω)	dR/dT (Ω/K)	dlogR/dlogT	Temp (K)	Res. (Ω)	dR/dT (Ω/K)	dlogR/dlogT
1.200	36.6021	-23.432	-0.76823	3.200	20.7914	-2.6489	-0.40769
1.300	34.5514	-18.771	-0.70627	3.300	20.5359	-2.4641	-0.39596
1.400	32.7579	-16.701	-0.71376	3.400	20.2980	-2.2972	-0.38478
1.500	31.2344	-13.921	-0.66852	3.500	20.0760	-2.1463	-0.37418
1.600	29.9461	-11.972	-0.63968	3.600	19.8683	-2.0099	-0.36419
1.700	28.8227	-10.543	-0.62182	3.700	19.6736	-1.8861	-0.35472
1.800	27.8286	-9.3806	-0.60675	3.800	19.4907	-1.7731	-0.34568
1.900	26.9409	-8.3889	-0.59162	3.900	19.3187	-1.6692	-0.33698
2.000	26.1482	-7.4762	-0.57183	4.000	19.1566	-1.5730	-0.32846
2.100	25.4418	-6.6755	-0.55100	4.200	18.8597	-1.3995	-0.31166
2.200	24.8088	-6.0038	-0.53241	4.400	18.5956	-1.2449	-0.29455
2.300	24.2374	-5.4397	-0.51620	4.600	18.3608	-1.1053	-0.27692
2.400	23.7179	-4.9648	-0.50238	4.800	18.1525	-0.98005	-0.25915
2.500	23.2422	-4.5579	-0.49027	5.000	17.9678	-0.86841	-0.24166
2.600	22.8047	-4.2000	-0.47884				
2.700	22.4009	-3.8803	-0.46769				
2.800	22.0277	-3.5886	-0.45615				
2.900	21.6824	-3.3217	-0.44428				
3.000	21.3626	-3.0767	-0.43207				
3.100	21.0664	-2.8527	-0.41979				

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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:

Room Temperature:	4.46 Ω
Liquid Nitrogen:	3.48 Ω
Liquid Helium:	18.9 Ω

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

Recommended Operating Parameters:

For sensors calibrated by LSCI the current to the sensor is adjusted to maintain the sensor output voltage or power at the values listed on the Test Data page. In order to minimize possible self-heating errors, we suggest that these same guidelines be followed in using the sensor.

Lead Identification:

White:	I+
Black:	I-
Yellow:	V+
Green:	V-

To avoid possible damage to the sensor, do not exceed 1 Volt and do not exceed 100 mA current.

BREAKPOINTS 340 FORMAT

Calibration Report: 505707 Sales Order: 35105
Sensor Model: GR-200A-30-CD-1.15A Serial Number: 29931
Sensor Type: Germanium Resistor Temperature Range: 1.20K to 5.00K

Name: GR-200A-30-CD-1.15A
Serial number: 29931
Format: 4 ;Log Ohms/Kelvin
Limit: 5.0
Coefficient: 1 ;Negative

Point 1: 1.25443, 5.000
Point 2: 1.25937, 4.780
Point 3: 1.26437, 4.580
Point 4: 1.26995, 4.380
Point 5: 1.27677, 4.160

Point 6: 1.28336, 3.970
Point 7: 1.28901, 3.820
Point 8: 1.29510, 3.670
Point 9: 1.30171, 3.520
Point 10: 1.30889, 3.370

Point 11: 1.31619, 3.230
Point 12: 1.32412, 3.090
Point 13: 1.33277, 2.950
Point 14: 1.34220, 2.810
Point 15: 1.35247, 2.670

Point 16: 1.36367, 2.530
Point 17: 1.37590, 2.390
Point 18: 1.38835, 2.260
Point 19: 1.40097, 2.140
Point 20: 1.41487, 2.020

Point 21: 1.43029, 1.900
Point 22: 1.44732, 1.780
Point 23: 1.46605, 1.660
Point 24: 1.48509, 1.550
Point 25: 1.50443, 1.450

Point 26: 1.52650, 1.350
Point 27: 1.55530, 1.230
Point 28: 1.56352, 1.200

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BREAKPOINTS 91C/93C/330 FORMAT

Calibration Report: 505707 Sales Order: 35105
Sensor Model: GR-200A-30-CD-1.15A Serial Number: 29931
Sensor Type: Germanium Resistor Temperature Range: 1.20K to 5.00K

Interpolation Method: Lagrangian
Limit: 5.0 (Kelvin)
Format: 4 (Log Ohms/Kelvin)
Number of Breakpoints: 16

No.	Units	Temperature (K)	No.	Units	Temperature (K)
1	1.25450	5.0	11	1.43041	1.9
2	1.25665	4.9	12	1.45974	1.7
3	1.26389	4.6	13	1.47634	1.6
4	1.27239	4.3	14	1.49463	1.5
5	1.28232	4.0	15	1.53847	1.3
6	1.29816	3.6	16	1.56351	1.2
7	1.31788	3.2			
8	1.33611	2.9			
9	1.35802	2.6			
10	1.39461	2.2			

Temperature for Resistance Decades:

Res. (Ohms)	Temp. (K)

BREAKPOINTS 234 FORMAT

Calibration Report: 505707 Sales Order: 35105

Sensor Model: GR-200A-30-CD-1.15A Serial Number: 29931

Sensor Type: Germanium Resistor Temperature Range: 1.20K to 5.00K

Maximum Temperature Error:

1.4 - 10K:	0.046K
10 - 20K:	-
20 - 40K:	-
40 - 100K:	-
> 100K:	-

BP #	Temp. (K)	Res. (Ω)	Log10 Res.	BP #	Temp. (K)	Res. (Ω)	Log10 Res.
1	5.868	17.37801	1.240	11	1.831	27.54229	1.440
2	4.756	18.19701	1.260	12	1.698	28.84032	1.460
3	4.066	19.05461	1.280	13	1.579	30.19952	1.480
4	3.559	19.95262	1.300	14	1.474	31.62278	1.500
5	3.162	20.89296	1.320	15	1.379	33.11311	1.520
6	2.843	21.87762	1.340	16	1.294	34.67369	1.540
7	2.575	22.90868	1.360	17	1.213	36.30781	1.560
8	2.347	23.98833	1.380	18	1.144	38.01894	1.580
9	2.150	25.11886	1.400	19	1.080	39.81072	1.600
10	1.980	26.30268	1.420				

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