

## CALIBRATION CERTIFICATE

Report Number: 848108

Sensor Model: RX-202A-AA-0.05B	Serial Number: U04844
Sensor Type: Ruthenium Oxide Resistor	Sales Order: 104256
Sensor Excitation: see <i>Test Data</i> page of report	Date: September 11, 2015
Temperature Range: 0.05 K to 40.0 K	Due: September 10, 2016

### 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: Todd Rittershausen  
Calibration Engineer/Technician

Approved by: Scott Courts  
Metrology



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# DATA PLOT

Calibration Report: 848108

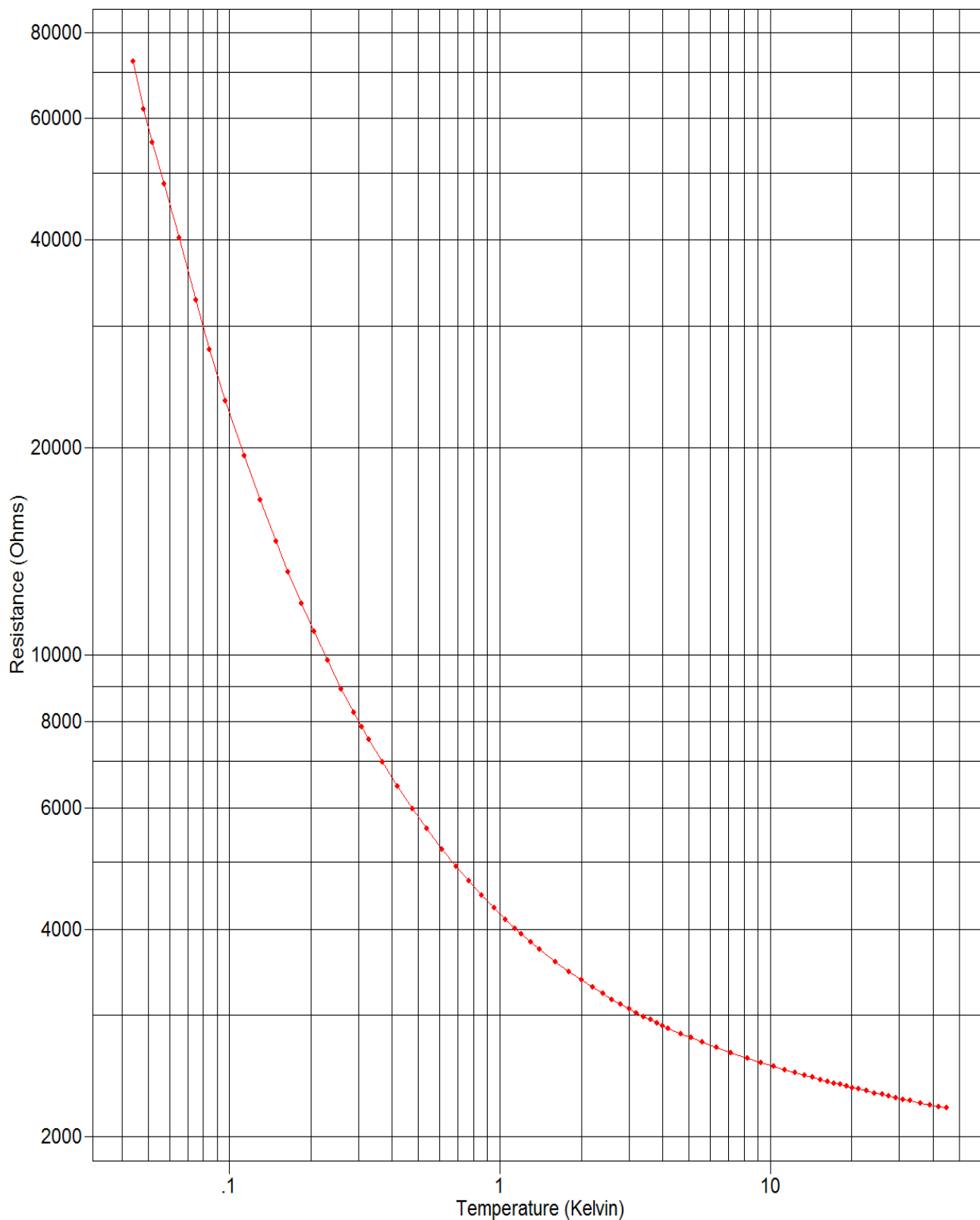
Sensor Model: RX-202A-AA-0.05B

Sensor Type: Ruthenium Oxide Resistor

Sales Order: 104256

Serial Number: U04844

Temperature Range: 0.05 K to 40.0 K



## TEST DATA

Calibration Report: 848108

Sensor Model: RX-202A-AA-0.05B

Sensor Type: Ruthenium Oxide Resistor

Sales Order: 104256

Serial Number: U04844

Temperature Range: 0.05 K to 40.0 K

Index	Temp. (K)	Resistance ( $\Omega$ )	Excitation	Index	Temp. (K)	Resistance ( $\Omega$ )	Excitation
1	4.39446e-2	72661.0	< 20 $\mu$ V	46	4.00485	2899.35	2mV25%
2	4.81450e-2	61847.0	< 20 $\mu$ V	47	4.20024	2875.25	2mV25%
3	5.17685e-2	55387.0	< 20 $\mu$ V	48	4.68209	2822.62	2mV25%
4	5.72385e-2	48223.0	< 20 $\mu$ V	49	5.09247	2784.58	2mV25%
5	6.52682e-2	40232.8	< 20 $\mu$ V	50	5.60909	2743.42	2mV25%
6	7.52427e-2	32705.7	< 20 $\mu$ V	51	6.32926	2695.22	2mV25%
7	8.43601e-2	27731.5	< 20 $\mu$ V	52	7.16743	2649.54	2mV25%
8	9.64902e-2	23412.3	< 20 $\mu$ V	53	8.21849	2602.79	2mV25%
9	0.113167	19480.7	< 63 $\mu$ V	54	9.27085	2564.02	2mV25%
10	0.129846	16790.5	< 63 $\mu$ V	55	10.3171	2531.34	2mV25%
11	0.148502	14629.6	< 63 $\mu$ V	56	11.3512	2503.53	2mV25%
12	0.164355	13231.2	< 63 $\mu$ V	57	12.3656	2479.29	2mV25%
13	0.184004	11893.9	< 63 $\mu$ V	58	13.3650	2458.20	2mV25%
14	0.205191	10793.0	< 63 $\mu$ V	59	14.3505	2439.27	2mV25%
15	0.230276	9797.80	< 63 $\mu$ V	60	15.3249	2422.36	2mV25%
16	0.259542	8915.90	< 63 $\mu$ V	61	16.2862	2407.16	2mV25%
17	0.288824	8236.50	< 63 $\mu$ V	62	17.2426	2393.18	2mV25%
18	0.308836	7848.40	< 63 $\mu$ V	63	18.1918	2380.37	2mV25%
19	0.328396	7524.30	< 63 $\mu$ V	64	19.1410	2368.32	2mV25%
20	0.366819	6993.50	< 63 $\mu$ V	65	20.0962	2357.21	2mV25%
21	0.417096	6451.90	< 63 $\mu$ V	66	21.1577	2345.61	2mV25%
22	0.475900	5971.80	< 63 $\mu$ V	67	22.7262	2330.12	2mV25%
23	0.536234	5590.70	< 63 $\mu$ V	68	24.3302	2315.54	2mV25%
24	0.610995	5226.00	< 63 $\mu$ V	69	25.9228	2302.40	2mV25%
25	0.688087	4934.51	< 63 $\mu$ V	70	27.5203	2290.35	2mV25%
26	0.766549	4699.12	< 63 $\mu$ V	71	29.1173	2279.13	2mV25%
27	0.856363	4479.81	< 63 $\mu$ V	72	30.9167	2267.69	2mV25%
28	0.950369	4294.45	< 63 $\mu$ V	73	33.0262	2255.34	2mV25%
29	1.04856	4134.25	< 63 $\mu$ V	74	36.0177	2239.48	2mV25%
30	1.14022	4007.75	< 63 $\mu$ V	75	39.0231	2225.47	2mV25%
31	1.20129	3937.27	2mV25%	76	42.0146	2212.99	2mV25%
32	1.30090	3832.43	2mV25%	77	45.0197	2201.78	2mV25%
33	1.39915	3742.32	2mV25%				
34	1.59985	3590.14	2mV25%				
35	1.80061	3469.89	2mV25%				
36	2.00065	3372.72	2mV25%				
37	2.20109	3291.66	2mV25%				
38	2.39963	3223.44	2mV25%				
39	2.60010	3163.74	2mV25%				
40	2.80027	3111.90	2mV25%				
41	3.00360	3065.63	2mV25%				
42	3.20224	3025.26	2mV25%				
43	3.40058	2989.47	2mV25%				
44	3.60046	2956.73	2mV25%				
45	3.80066	2927.18	2mV25%				



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# UNCERTAINTY ANALYSIS

Calibration Report: 848108

Sensor Model: RX-202A-AA-0.05B

Sensor Type: Ruthenium Oxide Resistor

Sales Order: 104256

Serial Number: U04844

Temperature Range: 0.05 K to 40.0 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/NCSS 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 $\Omega$	25 $\Omega$	27 $\Omega$	
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

$\sigma_{fit}$  = 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

$\Delta T_{RMS}$  = root mean square deviation of fit

A value of  $\Delta T_{RMS}$  is given for each range of fit.

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## POLYNOMIAL EQUATION

Calibration Report: 848108

Sensor Model: RX-202A-AA-0.05B

Sensor Type: Ruthenium Oxide Resistor

Sales Order: 104256

Serial Number: U04844

Temperature Range: 0.05 K to 40.0 K

Polynomial Type: Chebychev

Useful Range of Fit:

5.00e-2 K to 0.857 K  
5.829e+4 ohms to 4480 ohms

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

ZL = 3.61639673507

ZU = 4.86130137056

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	0.289503	2.4113E-05	12005.94
1	-0.380156	3.8766E-05	-9806.39
2	0.201038	3.6461E-05	5513.79
3	-0.097604	3.3664E-05	-2899.35
4	0.044864	3.1363E-05	1430.45
5	-0.020093	2.9201E-05	-688.11
6	0.008971	2.8925E-05	310.16
7	-0.003591	2.9768E-05	-120.63
8	0.001755	3.1872E-05	55.05
9	-0.000831	3.3024E-05	-25.16
10	0.000091	3.1518E-05	2.89

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

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

Temp. (K) =  $\sum A_i * \text{COS}(i * \text{ARCCOS}(k))$ , where  $0 \leq i \leq 10$   
and the  $A_i$ 's are the coefficients in the table above.



## POLYNOMIAL EQUATION

Calibration Report: 848108

Sales Order: 104256

Sensor Model: RX-202A-AA-0.05B

Serial Number: U04844

Sensor Type: Ruthenium Oxide Resistor

Temperature Range: 0.05 K to 40.0 K

Polynomial Type: Chebychev

Temp. (K) vs. Log(Resistance)

	R Meas. ( $\Omega$ )	T Meas. (K)	T Eq. (K)	T diff. (mK)
1	72661.00	0.04394	0.04395	0.00
2	61847.00	0.04814	0.04814	0.01
3	55387.00	0.05177	0.05176	0.00
4	48223.00	0.05724	0.05726	-0.03
5	40232.80	0.06527	0.06526	0.01
6	32705.70	0.07524	0.07517	0.07
7	27731.50	0.08436	0.08448	-0.12
8	23412.30	0.09649	0.09645	0.04
9	19480.70	0.11317	0.11312	0.04
10	16790.50	0.12985	0.12987	-0.02
11	14629.60	0.14850	0.14847	0.03
12	13231.20	0.16435	0.16438	-0.03
13	11893.90	0.18400	0.18405	-0.04
14	10793.00	0.20519	0.20521	-0.02
15	9797.800	0.23028	0.23025	0.03
16	8915.900	0.25954	0.25950	0.04
17	8236.500	0.28882	0.28870	0.13
18	7848.400	0.30884	0.30895	-0.12
19	7524.300	0.32840	0.32843	-0.03
20	6993.500	0.36682	0.36678	0.04
21	6451.900	0.41710	0.41718	-0.08
22	5971.800	0.47590	0.47583	0.07
23	5590.700	0.53623	0.53624	-0.01
24	5226.000	0.61100	0.61105	-0.05
25	4934.510	0.68809	0.68814	-0.05
26	4699.120	0.76655	0.76627	0.28
27	4479.810	0.85636	0.85656	-0.19
28	4294.450	0.95037	0.95043	-0.06
29	4134.250	1.04856	1.04850	0.06

Order of Fit = 10

RMS error of fit = 0.08 mK

Largest absolute error = 0.28 mK at data point no. 26



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## POLYNOMIAL EQUATION

Calibration Report: 848108

Sensor Model: RX-202A-AA-0.05B

Sensor Type: Ruthenium Oxide Resistor

Sales Order: 104256

Serial Number: U04844

Temperature Range: 0.05 K to 40.0 K

Polynomial Type: Chebychev

Useful Range of Fit:

0.856 K to 6.33 K  
4480 ohms to 2695 ohms

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

ZL = 3.41543990211

ZU = 3.69324403343

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	2.811836	2.4713E-04	11377.87
1	-3.108628	4.2683E-04	-7283.03
2	1.395386	3.7582E-04	3712.92
3	-0.569119	3.3634E-04	-1692.08
4	0.217291	2.9831E-04	728.41
5	-0.078183	2.7967E-04	-279.55
6	0.026229	2.9298E-04	89.53
7	-0.008416	3.1497E-04	-26.72
8	0.002555	3.2333E-04	7.90
9	-0.000845	3.1603E-04	-2.67

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

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

Temp. (K) =  $\sum A_i \cdot \cos(i \cdot \arccos(k))$ , where  $0 \leq i \leq 9$   
and the  $A_i$ 's are the coefficients in the table above.



## POLYNOMIAL EQUATION

Calibration Report: 848108

Sales Order: 104256

Sensor Model: RX-202A-AA-0.05B

Serial Number: U04844

Sensor Type: Ruthenium Oxide Resistor

Temperature Range: 0.05 K to 40.0 K

Polynomial Type: Chebychev

Temp. (K) vs. Log(Resistance)

	R Meas. ( $\Omega$ )	T Meas. (K)	T Eq. (K)	T diff. (mK)
25	4934.510	0.68814	0.68811	0.03
26	4699.120	0.76627	0.76644	-0.18
27	4479.810	0.85656	0.85625	0.31
28	4294.450	0.95037	0.95023	0.14
29	4134.250	1.04856	1.04880	-0.24
30	4007.750	1.14022	1.14166	-1.44
31	3937.268	1.20129	1.20060	0.69
32	3832.429	1.30090	1.29989	1.01
33	3742.320	1.39915	1.39847	0.68
34	3590.140	1.59985	1.60047	-0.62
35	3469.892	1.80061	1.80178	-1.17
36	3372.720	2.00065	2.00116	-0.51
37	3291.661	2.20109	2.20060	0.50
38	3223.441	2.39963	2.39836	1.27
39	3163.738	2.60010	2.59945	0.64
40	3111.897	2.80027	2.80001	0.26
41	3065.632	3.00360	3.00352	0.07
42	3025.255	3.20224	3.20352	-1.28
43	2989.468	3.40058	3.40117	-0.59
44	2956.733	3.60046	3.60134	-0.88
45	2927.177	3.80066	3.80027	0.39
46	2899.351	4.00485	4.00549	-0.64
47	2875.254	4.20024	4.19904	1.20
48	2822.621	4.68209	4.68177	0.33
49	2784.584	5.09247	5.09209	0.38
50	2743.419	5.60909	5.60823	0.86
51	2695.220	6.32926	6.33119	-1.93
52	2649.543	7.16743	7.16672	0.72
53	2602.795	8.21849	8.21849	0.00

Order of Fit = 9      RMS error of fit = 0.80 mK

Largest absolute error = -1.93 mK at data point no. 51



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## POLYNOMIAL EQUATION

Calibration Report: 848108

Sensor Model: RX-202A-AA-0.05B

Sensor Type: Ruthenium Oxide Resistor

Sales Order: 104256

Serial Number: U04844

Temperature Range: 0.05 K to 40.0 K

Polynomial Type: Chebychev

Useful Range of Fit:

6.33 K to 40.0 K  
2695 ohms to 2221 ohms

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

ZL = 3.34277304673

ZU = 3.44476032678

Order	Coefficient	Std. Deviation of Coefficient	Ratio (Coeff./Std Dev.)
0	18.282661	1.3311E-03	13734.92
1	-18.014011	2.1997E-03	-8189.23
2	6.237350	1.9278E-03	3235.48
3	-1.801806	1.8278E-03	-985.77
4	0.494870	1.7135E-03	288.81
5	-0.129637	1.6629E-03	-77.96
6	0.033922	1.6444E-03	20.63
7	-0.013169	1.6746E-03	-7.86
8	0.006285	1.6804E-03	3.74
9	-0.004530	1.6745E-03	-2.71

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

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

Temp. (K) =  $\sum A_i \cdot \cos(i \cdot \arccos(k))$ , where  $0 \leq i \leq 9$   
and the  $A_i$ 's are the coefficients in the table above.



## POLYNOMIAL EQUATION

Calibration Report: 848108

Sales Order: 104256

Sensor Model: RX-202A-AA-0.05B

Serial Number: U04844

Sensor Type: Ruthenium Oxide Resistor

Temperature Range: 0.05 K to 40.0 K

Polynomial Type: Chebychev

Temp. (K) vs. Log(Resistance)

	R Meas. ( $\Omega$ )	T Meas. (K)	T Eq. (K)	T diff. (mK)
49	2784.584	5.09209	5.09194	0.15
50	2743.419	5.60823	5.60903	-0.80
51	2695.220	6.33119	6.32926	1.93
52	2649.543	7.16743	7.16945	-2.02
53	2602.795	8.21849	8.21821	0.29
54	2564.019	9.27085	9.27030	0.56
55	2531.336	10.31714	10.31775	-0.62
56	2503.528	11.35119	11.34809	3.11
57	2479.292	12.36556	12.36836	-2.80
58	2458.198	13.36503	13.36344	1.59
59	2439.275	14.35048	14.35356	-3.08
60	2422.359	15.32493	15.32758	-2.65
61	2407.160	16.28623	16.28377	2.46
62	2393.178	17.24255	17.23966	2.89
63	2380.371	18.19182	18.18663	5.18
64	2368.324	19.14103	19.14656	-5.53
65	2357.211	20.09624	20.09734	-1.10
66	2345.605	21.15773	21.16381	-6.08
67	2330.121	22.72622	22.71615	10.07
68	2315.540	24.33019	24.32944	0.75
69	2302.404	25.92281	25.92442	-1.61
70	2290.353	27.52033	27.51958	0.76
71	2279.135	29.11729	29.13059	-13.30
72	2267.693	30.91673	30.91317	3.56
73	2255.339	33.02615	33.01481	11.34
74	2239.484	36.01765	36.02214	-4.49
75	2225.469	39.02306	39.02245	0.61
76	2212.990	42.01458	42.01728	-2.69
77	2201.776	45.01975	45.01824	1.51

Order of Fit = 9      RMS error of fit = 4.58 mK

Largest absolute error = -13.30 mK at data point no. 71



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# INTERPOLATION TABLE

Calibration Report: 848108

Sensor Model: RX-202A-AA-0.05B

Sensor Type: Ruthenium Oxide Resistor

Sales Order: 104256

Serial Number: U04844

Temperature Range: 0.05 K to 40.0 K

<u>Temp (K)</u>	<u>Res. (<math>\Omega</math>)</u>	<u>dR/dT (<math>\Omega</math>/K)</u>	<u>dlogR/dlogT</u>	<u>Temp (K)</u>	<u>Res. (<math>\Omega</math>)</u>	<u>dR/dT (<math>\Omega</math>/K)</u>	<u>dlogR/dlogT</u>
5.000e-2	58286.4	-1.7630e+6	-1.5124	1.300	3832.32	-978.91	-0.33207
5.500e-2	50916.1	-1.2530e+6	-1.3535	1.400	3741.01	-852.14	-0.31890
6.000e-2	45256.3	-1.0357e+6	-1.3731	1.500	3661.08	-749.73	-0.30718
6.500e-2	40460.7	-8.8967e+5	-1.4292	1.600	3590.45	-665.84	-0.29672
7.000e-2	36324.6	-7.6448e+5	-1.4732	1.700	3527.44	-596.25	-0.28735
7.500e-2	32814.9	-6.3987e+5	-1.4625	1.800	3470.85	-537.24	-0.27862
8.000e-2	29905.1	-5.2776e+5	-1.4118	1.900	3419.70	-486.92	-0.27054
8.500e-2	27504.3	-4.3551e+5	-1.3459	2.000	3373.23	-443.54	-0.26298
9.000e-2	25517.0	-3.6269e+5	-1.2792	2.100	3330.80	-405.95	-0.25595
9.500e-2	23848.2	-3.0744e+5	-1.2247	2.200	3291.88	-373.10	-0.24935
0.1000	22420.6	-2.6522e+5	-1.1829	2.300	3256.04	-344.28	-0.24319
0.1100	20095.9	-2.0422e+5	-1.1179	2.400	3222.92	-318.82	-0.23741
0.1200	18264.5	-1.6440e+5	-1.0801	2.500	3192.18	-296.25	-0.23201
0.1300	16772.2	-1.3557e+5	-1.0508	2.600	3163.59	-276.12	-0.22693
0.1400	15529.6	-1.1382e+5	-1.0261	2.700	3136.89	-258.12	-0.22217
0.1500	14480.2	-96752	-1.0022	2.800	3111.90	-241.94	-0.21769
0.1600	13583.6	-83037	-0.97809	2.900	3088.45	-227.35	-0.21347
0.1700	12811.1	-71829	-0.95315	3.000	3066.39	-214.12	-0.20949
0.1800	12140.5	-62577	-0.92779	3.100	3045.58	-202.12	-0.20573
0.1900	11554.2	-54916	-0.90306	3.200	3025.93	-191.16	-0.20216
0.2000	11038.0	-48508	-0.87892	3.300	3007.32	-181.15	-0.19879
0.2100	10580.6	-43141	-0.85626	3.400	2989.67	-171.97	-0.19557
0.2200	10172.5	-38592	-0.83462	3.500	2972.90	-163.53	-0.19252
0.2300	9806.41	-34736	-0.81471	3.600	2956.94	-155.74	-0.18961
0.2400	9475.92	-31440	-0.79630	3.700	2941.73	-148.54	-0.18683
0.2500	9176.12	-28589	-0.77889	3.800	2927.22	-141.88	-0.18418
0.2600	8902.84	-26130	-0.76312	3.900	2913.34	-135.69	-0.18164
0.2700	8652.47	-23987	-0.74852	4.000	2900.06	-129.93	-0.17920
0.2800	8422.24	-22099	-0.73467	4.200	2875.14	-119.56	-0.17466
0.2900	8209.74	-20439	-0.72198	4.400	2852.15	-110.48	-0.17044
0.3000	8012.85	-18966	-0.71010	4.600	2830.88	-102.46	-0.16649
0.3200	7659.35	-16475	-0.68831	4.800	2811.10	-95.416	-0.16292
0.3400	7350.65	-14461	-0.66890	5.000	2792.66	-89.089	-0.15951
0.3600	7078.58	-12799	-0.65092	5.200	2775.42	-83.428	-0.15631
0.3800	6836.78	-11421	-0.63479	5.400	2759.25	-78.389	-0.15341
0.4000	6620.39	-10250	-0.61927	5.600	2744.03	-73.952	-0.15092
0.4200	6425.60	-9256.8	-0.60506	5.800	2729.64	-69.939	-0.14861
0.4400	6249.22	-8401.3	-0.59153	6.000	2716.04	-66.151	-0.14613
0.4600	6088.81	-7656.4	-0.57843	6.500	2685.15	-57.669	-0.13960
0.4800	5942.30	-7010.6	-0.56629	7.000	2658.04	-51.074	-0.13450
0.5000	5807.88	-6442.4	-0.55463	7.500	2633.78	-46.163	-0.13146
0.5500	5515.97	-5292.8	-0.52774	8.000	2611.77	-41.962	-0.12853
0.6000	5273.99	-4426.0	-0.50353	8.500	2591.71	-38.352	-0.12578
0.6500	5069.94	-3762.5	-0.48238	9.000	2573.34	-35.232	-0.12322
0.7000	4895.41	-3239.5	-0.46322	9.500	2556.41	-32.559	-0.12100
0.7500	4744.16	-2826.9	-0.44690	10.00	2540.72	-30.220	-0.11894
0.8000	4611.28	-2498.2	-0.43341	10.50	2526.14	-28.179	-0.11713
0.8500	4493.57	-2217.5	-0.41946	11.00	2512.51	-26.371	-0.11545
0.9000	4388.81	-1980.0	-0.40603	11.50	2499.73	-24.772	-0.11397
0.9500	4294.86	-1785.0	-0.39484	12.00	2487.71	-23.338	-0.11257
1.000	4209.80	-1620.5	-0.38494	12.50	2476.37	-22.048	-0.11129
1.050	4132.48	-1475.7	-0.37494	13.00	2465.64	-20.876	-0.11007
1.100	4061.94	-1348.6	-0.36520	13.50	2455.47	-19.809	-0.10891
1.150	3997.35	-1237.6	-0.35605	14.00	2445.82	-18.830	-0.10779
1.200	3937.95	-1140.4	-0.34752	14.50	2436.63	-17.931	-0.10670



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# INTERPOLATION TABLE

Calibration Report: 848108

Sensor Model: RX-202A-AA-0.05B

Sensor Type: Ruthenium Oxide Resistor

Sales Order: 104256

Serial Number: U04844

Temperature Range: 0.05 K to 40.0 K

<u>Temp (K)</u>	<u>Res. (<math>\Omega</math>)</u>	<u>dR/dT (<math>\Omega</math>/K)</u>	<u>dlogR/dlogT</u>	<u>Temp (K)</u>	<u>Res. (<math>\Omega</math>)</u>	<u>dR/dT (<math>\Omega</math>/K)</u>	<u>dlogR/dlogT</u>
15.00	2427.88	-17.099	-0.10564	30.00	2273.43	-6.4224	-8.4749e-2
15.50	2419.52	-16.330	-0.10461	31.00	2267.16	-6.1336	-8.3867e-2
16.00	2411.54	-15.615	-0.10360	32.00	2261.16	-5.8653	-8.3005e-2
16.50	2403.90	-14.951	-0.10262	33.00	2255.42	-5.6156	-8.2163e-2
17.00	2396.58	-14.331	-0.10166	34.00	2249.92	-5.3822	-8.1334e-2
17.50	2389.56	-13.753	-0.10072	35.00	2244.65	-5.1628	-8.0502e-2
18.00	2382.82	-13.213	-9.9810e-2	36.00	2239.59	-4.9573	-7.9686e-2
18.50	2376.34	-12.707	-9.8926e-2	37.00	2234.73	-4.7641	-7.8878e-2
19.00	2370.11	-12.233	-9.8065e-2	38.00	2230.06	-4.5813	-7.8065e-2
19.50	2364.10	-11.788	-9.7233e-2	39.00	2225.57	-4.4089	-7.7260e-2
20.00	2358.31	-11.370	-9.6426e-2	40.00	2221.24	-4.2457	-7.6457e-2
21.00	2347.33	-10.607	-9.4894e-2				
22.00	2337.07	-9.9288	-9.3464e-2				
23.00	2327.45	-9.3234	-9.2135e-2				
24.00	2318.40	-8.7795	-9.0885e-2				
25.00	2309.87	-8.2900	-8.9723e-2				
26.00	2301.81	-7.8462	-8.8626e-2				
27.00	2294.17	-7.4423	-8.7588e-2				
28.00	2286.91	-7.0734	-8.6604e-2				
29.00	2280.01	-6.7345	-8.5658e-2				



## THERMAL CYCLE TESTING

Calibration Report: 848108

Sales Order: 104256

Sensor Model: RX-202A-AA-0.05B

Serial Number: U04844

Sensor Type: Ruthenium Oxide 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:	2014 $\Omega$
Liquid Nitrogen:	2121 $\Omega$
Liquid Helium:	2870 $\Omega$

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: 848108

Sensor Model: RX-202A-AA-0.05B

Sensor Type: Ruthenium Oxide Resistor

Sales Order: 104256

Serial Number: U04844

Temperature Range: 0.05 K to 40.0 K

Sensor Model: RX-202A-AA-0.05B  
Serial Number: U04844  
Data Format: 7 (Ohms/Kelvin)  
Setpoint Limit: 40

Measurement (ohms)	Temp (K)	Curvature	Measurement (ohms)	Temp (K)	Curvature
2.20178E+03	4.50182E+01	2.69907E-03	5.97180E+03	4.75829E-01	8.42099E-08
2.21299E+03	4.20173E+01	2.34435E-03	6.45190E+03	4.17179E-01	5.57434E-08
2.22547E+03	3.90225E+01	1.94962E-03	6.99350E+03	3.66780E-01	3.75005E-08
2.23948E+03	3.60221E+01	1.63195E-03	7.52430E+03	3.28431E-01	2.67916E-08
2.25534E+03	3.30148E+01	1.35919E-03	7.84840E+03	3.08955E-01	2.22929E-08
2.26769E+03	3.09132E+01	1.19706E-03	8.23650E+03	2.88697E-01	1.78657E-08
2.27913E+03	2.91306E+01	1.07085E-03	8.91590E+03	2.59501E-01	1.25822E-08
2.29035E+03	2.75196E+01	9.66398E-04	9.79780E+03	2.30248E-01	8.37845E-09
2.30240E+03	2.59244E+01	8.69720E-04	1.07930E+04	2.05210E-01	5.54570E-09
2.31554E+03	2.43294E+01	7.78663E-04	1.18939E+04	1.84048E-01	3.66046E-09
2.33012E+03	2.27162E+01	6.90811E-04	1.32312E+04	1.64382E-01	2.35346E-09
2.34561E+03	2.11638E+01	6.09750E-04	1.46296E+04	1.48474E-01	1.57688E-09
2.35721E+03	2.00973E+01	5.55767E-04	1.67905E+04	1.29865E-01	9.58409E-10
2.36832E+03	1.91466E+01	5.08333E-04	1.94807E+04	1.13122E-01	6.02220E-10
2.38037E+03	1.81866E+01	4.61660E-04	2.34123E+04	9.64495E-02	3.42031E-10
2.39318E+03	1.72397E+01	4.17005E-04	2.77315E+04	8.44834E-02	1.87481E-10
2.40716E+03	1.62838E+01	3.73706E-04	3.27057E+04	7.51712E-02	8.60383E-11
2.42236E+03	1.53276E+01	3.32633E-04	4.02328E+04	6.52570E-02	3.27118E-11
2.43927E+03	1.43536E+01	2.93591E-04	4.82230E+04	5.72640E-02	2.97599E-11
2.45820E+03	1.33634E+01	2.57281E-04	5.53870E+04	5.17637E-02	3.24089E-11
2.47929E+03	1.23684E+01	2.24382E-04	6.18470E+04	4.81396E-02	2.23236E-11
2.50353E+03	1.13481E+01	1.94148E-04	7.26610E+04	4.39461E-02	5.44075E-12
2.53134E+03	1.03178E+01	1.66065E-04			
2.56402E+03	9.27030E+00	1.38659E-04			
2.60279E+03	8.21821E+00	1.09649E-04			
2.64954E+03	7.16945E+00	8.68730E-05			
2.69522E+03	6.33119E+00	7.23948E-05			
2.74342E+03	5.60823E+00	5.29952E-05			
2.78458E+03	5.09209E+00	4.38912E-05			
2.82262E+03	4.68177E+00	3.60643E-05			
2.87525E+03	4.19904E+00	2.81994E-05			
2.89935E+03	4.00549E+00	2.54001E-05			
2.92718E+03	3.80027E+00	2.24406E-05			
2.95673E+03	3.60134E+00	1.97880E-05			
2.98947E+03	3.40117E+00	1.72811E-05			
3.02526E+03	3.20352E+00	1.49805E-05			
3.06563E+03	3.00352E+00	1.28225E-05			
3.11190E+03	2.80001E+00	1.08053E-05			
3.16374E+03	2.59945E+00	8.98974E-06			
3.22344E+03	2.39836E+00	7.34043E-06			
3.29166E+03	2.20060E+00	5.88604E-06			
3.37272E+03	2.00116E+00	4.59156E-06			
3.46989E+03	1.80178E+00	3.48037E-06			
3.59014E+03	1.60047E+00	2.54587E-06			
3.74232E+03	1.39847E+00	1.80809E-06			
3.83243E+03	1.29989E+00	1.51413E-06			
3.93727E+03	1.20060E+00	1.22673E-06			
4.00775E+03	1.14166E+00	1.07254E-06			
4.13425E+03	1.04880E+00	8.26516E-07			
4.29445E+03	9.50228E-01	6.41661E-07			
4.47981E+03	8.56555E-01	4.52238E-07			
4.69912E+03	7.66266E-01	3.51156E-07			
4.93451E+03	6.88136E-01	2.55568E-07			
5.22600E+03	6.11046E-01	1.80828E-07			
5.59070E+03	5.36243E-01	1.21653E-07			



# BREAKPOINTS 340 FORMAT

Calibration Report: 848108

Sensor Model: RX-202A-AA-0.05B

Sensor Type: Ruthenium Oxide Resistor

Sales Order: 104256

Serial Number: U04844

Temperature Range: 0.05 K to 40.0 K

Name: RX-202A-AA-0.05B  
Serial number: U04844  
Format: 4 ;Log Ohms/Kelvin  
Limit: 40.0  
Coefficient: 1 ;Negative

Point 1: 3.34659, 40.000	Point 51: 3.44227, 5.280	Point 101: 3.81293, 0.412
Point 2: 3.34778, 38.600	Point 52: 3.44600, 5.000	Point 102: 3.82490, 0.394
Point 3: 3.34895, 37.300	Point 53: 3.45004, 4.720	Point 103: 3.83771, 0.376
Point 4: 3.35016, 36.000	Point 54: 3.45447, 4.440	Point 104: 3.85145, 0.358
Point 5: 3.35145, 34.700	Point 55: 3.45899, 4.180	Point 105: 3.86456, 0.342
Point 6: 3.35269, 33.500	Point 56: 3.46298, 3.970	Point 106: 3.87859, 0.326
Point 7: 3.35399, 32.300	Point 57: 3.46644, 3.800	Point 107: 3.89367, 0.310
Point 8: 3.35536, 31.100	Point 58: 3.47014, 3.630	Point 108: 3.90995, 0.294
Point 9: 3.35680, 29.900	Point 59: 3.47412, 3.460	Point 109: 3.92647, 0.279
Point 10: 3.35832, 28.700	Point 60: 3.47816, 3.300	Point 110: 3.94437, 0.264
Point 11: 3.35979, 27.600	Point 61: 3.48250, 3.140	Point 111: 3.96255, 0.250
Point 12: 3.36133, 26.500	Point 62: 3.48691, 2.990	Point 112: 3.98231, 0.236
Point 13: 3.36296, 25.400	Point 63: 3.49166, 2.840	Point 113: 4.00241, 0.223
Point 14: 3.36469, 24.300	Point 64: 3.49682, 2.690	Point 114: 4.02434, 0.210
Point 15: 3.36636, 23.300	Point 65: 3.50207, 2.550	Point 115: 4.04850, 0.197
Point 16: 3.36812, 22.300	Point 66: 3.50778, 2.410	Point 116: 4.07310, 0.185
Point 17: 3.36998, 21.300	Point 67: 3.51358, 2.280	Point 117: 4.10015, 0.173
Point 18: 3.37197, 20.300	Point 68: 3.51990, 2.150	Point 118: 4.13013, 0.161
Point 19: 3.37345, 19.600	Point 69: 3.52686, 2.020	Point 119: 4.16340, 0.149
Point 20: 3.37476, 19.000	Point 70: 3.53394, 1.900	Point 120: 4.19733, 0.138
Point 21: 3.37614, 18.400	Point 71: 3.54173, 1.780	Point 121: 4.23495, 0.127
Point 22: 3.37745, 17.850	Point 72: 3.55038, 1.660	Point 122: 4.27322, 0.117
Point 23: 3.37882, 17.300	Point 73: 3.55921, 1.550	Point 123: 4.31617, 0.107
Point 24: 3.38024, 16.750	Point 74: 3.56902, 1.440	Point 124: 4.36326, 0.098
Point 25: 3.38173, 16.200	Point 75: 3.57905, 1.340	Point 125: 4.40936, 0.090
Point 26: 3.38329, 15.650	Point 76: 3.59026, 1.240	Point 126: 4.46005, 0.082
Point 27: 3.38492, 15.100	Point 77: 3.59780, 1.180	Point 127: 4.52377, 0.074
Point 28: 3.38647, 14.600	Point 78: 3.60310, 1.140	Point 128: 4.63015, 0.063
Point 29: 3.38809, 14.100	Point 79: 3.60871, 1.100	Point 129: 4.72225, 0.054
Point 30: 3.38978, 13.600	Point 80: 3.61465, 1.060	Point 130: 4.76529, 0.050
Point 31: 3.39156, 13.100	Point 81: 3.62094, 1.020	
Point 32: 3.39342, 12.600	Point 82: 3.62763, 0.980	
Point 33: 3.39539, 12.100	Point 83: 3.63474, 0.940	
Point 34: 3.39725, 11.650	Point 84: 3.64231, 0.900	
Point 35: 3.39920, 11.200	Point 85: 3.64939, 0.865	
Point 36: 3.40126, 10.750	Point 86: 3.65692, 0.830	
Point 37: 3.40343, 10.300	Point 87: 3.66497, 0.795	
Point 38: 3.40573, 9.850	Point 88: 3.67356, 0.760	
Point 39: 3.40790, 9.450	Point 89: 3.68275, 0.725	
Point 40: 3.41019, 9.050	Point 90: 3.69264, 0.690	
Point 41: 3.41262, 8.650	Point 91: 3.70178, 0.660	
Point 42: 3.41521, 8.250	Point 92: 3.71155, 0.630	
Point 43: 3.41798, 7.850	Point 93: 3.72208, 0.600	
Point 44: 3.42057, 7.500	Point 94: 3.73345, 0.570	
Point 45: 3.42332, 7.150	Point 95: 3.74577, 0.540	
Point 46: 3.42625, 6.800	Point 96: 3.75919, 0.510	
Point 47: 3.42896, 6.500	Point 97: 3.76986, 0.488	
Point 48: 3.43186, 6.200	Point 98: 3.78017, 0.468	
Point 49: 3.43520, 5.880	Point 99: 3.79116, 0.448	
Point 50: 3.43860, 5.580	Point 100: 3.80172, 0.430	



# BREAKPOINTS 234 FORMAT

Calibration Report: 848108

Sensor Model: RX-202A-AA-0.05B

Sensor Type: Ruthenium Oxide Resistor

Sales Order: 104256

Serial Number: U04844

Temperature Range: 0.05 K to 40.0 K

## Maximum Temperature Error:

1.4 - 10 K:	0.176 K
10 - 20 K:	1.275 K
20 - 40 K:	1.627 K
40 - 100 K:	-
> 100 K:	-

BP #	Temp. (K)	Res. ( $\Omega$ )	Log10 Res.	BP #	Temp. (K)	Res. ( $\Omega$ )	Log10 Res.
1	27.449	2290.868	3.360	16	0.252	9120.108	3.960
2	11.024	2511.886	3.400	17	0.225	10000.00	4.000
3	5.465	2754.229	3.440	18	0.173	12589.25	4.100
4	3.232	3019.952	3.480	19	0.137	15848.93	4.200
5	2.149	3311.311	3.520	20	0.111	19952.62	4.300
6	1.541	3630.781	3.560	21	0.091	25118.86	4.400
7	1.163	3981.072	3.600	22	0.077	31622.78	4.500
8	0.912	4365.158	3.640	23	0.066	39810.72	4.600
9	0.735	4786.301	3.680	24	0.056	50118.72	4.700
10	0.606	5248.075	3.720	25	0.048	63095.73	4.800
11	0.508	5754.399	3.760				
12	0.433	6309.573	3.800				
13	0.373	6918.310	3.840				
14	0.325	7585.776	3.880				
15	0.285	8317.638	3.920				



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