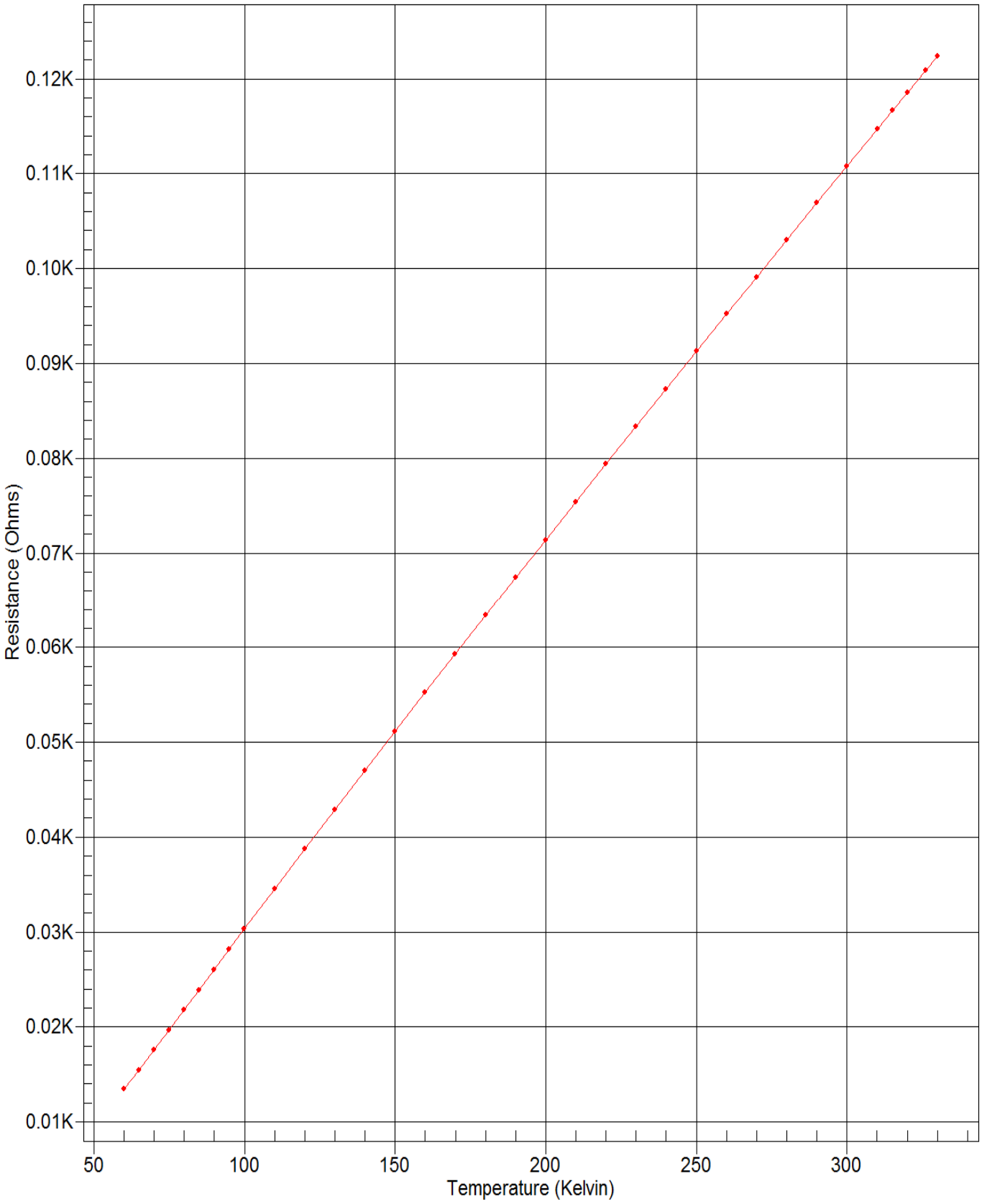
# DATA PLOT

Calibration Report: 562915
Sensor Model: PT-103-AM-70L
Sensor Type: Platinum Resistor

Sales Order: 50282
Serial Number: P15290
Temperature Range: 70.0K to 325K



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# TEST DATA

Calibration Report: 562915
Sensor Model: PT-103-AM-70L
Sensor Type: Platinum Resistor

Sales Order: 50282
Serial Number: P15290
Temperature Range: 70.0K to 325K

| Index | Temp. (K) | Resistance (Ω) | Excitation | Index | Temp. (K) | Resistance (Ω) | Excitation |
|---|---|---|---|---|---|---|---|
| 1 | 60.0048 | 12.9938 | 0.50mA±5% | 21 | 219.997 | 78.9383 | 0.50mA±5% |
| 2 | 65.0035 | 15.0298 | 0.50mA±5% | 22 | 229.988 | 82.9064 | 0.50mA±5% |
| 3 | 69.9981 | 17.1070 | 0.50mA±5% | 23 | 239.998 | 86.8692 | 0.50mA±5% |
| 4 | 74.9900 | 19.2110 | 0.50mA±5% | 24 | 249.991 | 90.8123 | 0.50mA±5% |
| 5 | 79.9885 | 21.3331 | 0.50mA±5% | 25 | 259.995 | 94.7466 | 0.50mA±5% |
| 6 | 84.9886 | 23.4628 | 0.50mA±5% | 26 | 269.999 | 98.6684 | 0.50mA±5% |
| 7 | 89.9878 | 25.5940 | 0.50mA±5% | 27 | 280.006 | 102.579 | 0.50mA±5% |
| 8 | 94.9861 | 27.7225 | 0.50mA±5% | 28 | 290.018 | 106.481 | 0.50mA±5% |
| 9 | 99.9901 | 29.8484 | 0.50mA±5% | 29 | 300.036 | 110.372 | 0.50mA±5% |
| 10 | 109.988 | 34.0764 | 0.50mA±5% | 30 | 310.050 | 114.250 | 0.50mA±5% |
| 11 | 119.986 | 38.2736 | 0.50mA±5% | 31 | 315.062 | 116.186 | 0.50mA±5% |
| 12 | 129.983 | 42.4404 | 0.50mA±5% | 32 | 320.065 | 118.121 | 0.50mA±5% |
| 13 | 139.982 | 46.5783 | 0.50mA±5% | 33 | 326.066 | 120.433 | 0.50mA±5% |
| 14 | 149.982 | 50.6912 | 0.50mA±5% | 34 | 330.075 | 121.975 | 0.50mA±5% |
| 15 | 159.986 | 54.7822 | 0.50mA±5% | | | | |
| 16 | 169.989 | 58.8522 | 0.50mA±5% | | | | |
| 17 | 179.990 | 62.9015 | 0.50mA±5% | | | | |
| 18 | 189.984 | 66.9320 | 0.50mA±5% | | | | |
| 19 | 199.989 | 70.9493 | 0.50mA±5% | | | | |
| 20 | 209.999 | 74.9532 | 0.50mA±5% | | | | |



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Calibration Report: 562915 Sales Order: 50282
Sensor Model: PT-103-AM-70L Serial Number: P15290
Sensor Type: Platinum Resistor Temperature Range: 70.0K to 325K

**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 $\sigma_{fit}$ = 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
$\Delta T_{RMS}$ = 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: 562915 Sales Order: 50282
Sensor Model: PT-103-AM-70L Serial Number: P15290
Sensor Type: Platinum Resistor Temperature Range: 70.0K to 325K

Polynomial Type: Chebychev
Useful Range of Fit:

| | | |
|---|---|---|
| 70.0 K | to | 325. K |
| 17.11 Ohms | to | 120.0 Ohms |

Lower and Upper limits of Resistance used in computing Chebychev coefficients:
ZL = 12.99384249854 ZU = 121.97501907048

| Order | Coefficient | Std. Deviation of Coefficient | Ratio (Coeff./Std Dev.) |
|---|---|---|---|
| 0 | 193.289671 | 2.5087E-04 | 770463.06 |
| 1 | 134.988204 | 3.8584E-04 | 349851.66 |
| 2 | 1.903329 | 3.6982E-04 | 5146.66 |
| 3 | -0.080695 | 3.6769E-04 | -219.46 |
| 4 | -0.076356 | 3.5547E-04 | -214.80 |
| 5 | 0.088881 | 3.4535E-04 | 257.36 |
| 6 | -0.061112 | 3.4021E-04 | -179.63 |
| 7 | 0.030653 | 3.3561E-04 | 91.33 |
| 8 | -0.013841 | 3.3182E-04 | -41.71 |
| 9 | 0.006100 | 3.3418E-04 | 18.25 |
| 10 | -0.001660 | 3.3720E-04 | -4.92 |
| 11 | 0.001770 | 3.3602E-04 | 5.27 |

Z = Resistance

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

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

# POLYNOMIAL EQUATION

Calibration Report: 562915 Sales Order: 50282
Sensor Model: PT-103-AM-70L Serial Number: P15290
Sensor Type: Platinum Resistor Temperature Range: 70.0K to 325K

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

| | R Meas. (Ω) | T Meas. (K) | T Eq. (K) | T diff. (mK) |
|---|---|---|---|---|
| 1 | 12.99384 | 60.00477 | 60.00512 | -0.35 |
| 2 | 15.02976 | 65.00350 | 65.00276 | 0.74 |
| 3 | 17.10703 | 69.99805 | 69.99774 | 0.31 |
| 4 | 19.21102 | 74.99001 | 74.99090 | -0.89 |
| 5 | 21.33305 | 79.98850 | 79.98918 | -0.68 |
| 6 | 23.46282 | 84.98864 | 84.98831 | 0.33 |
| 7 | 25.59401 | 89.98781 | 89.98732 | 0.48 |
| 8 | 27.72249 | 94.98613 | 94.98571 | 0.42 |
| 9 | 29.84844 | 99.99009 | 99.98970 | 0.39 |
| 10 | 34.07640 | 109.98760 | 109.98860 | -1.01 |
| 11 | 38.27357 | 119.98640 | 119.98618 | 0.22 |
| 12 | 42.44038 | 129.98340 | 129.98411 | -0.70 |
| 13 | 46.57826 | 139.98220 | 139.98154 | 0.66 |
| 14 | 50.69119 | 149.98248 | 149.98187 | 0.61 |
| 15 | 54.78223 | 159.98591 | 159.98603 | -0.11 |
| 16 | 58.85224 | 169.98931 | 169.99003 | -0.72 |
| 17 | 62.90151 | 179.99040 | 179.98958 | 0.82 |
| 18 | 66.93195 | 189.98440 | 189.98551 | -1.11 |
| 19 | 70.94931 | 199.98921 | 199.98932 | -0.11 |
| 20 | 74.95320 | 209.99860 | 209.99807 | 0.53 |
| 21 | 78.93830 | 219.99731 | 219.99658 | 0.73 |
| 22 | 82.90637 | 229.98771 | 229.98746 | 0.24 |
| 23 | 86.86924 | 239.99834 | 239.99879 | -0.45 |
| 24 | 90.81227 | 249.99116 | 249.99224 | -1.08 |
| 25 | 94.74663 | 259.99477 | 259.99522 | -0.45 |
| 26 | 98.66841 | 269.99897 | 269.99776 | 1.21 |
| 27 | 102.5794 | 280.00610 | 280.00467 | 1.43 |
| 28 | 106.4808 | 290.01815 | 290.01937 | -1.21 |
| 29 | 110.3716 | 300.03560 | 300.03716 | -1.56 |
| 30 | 114.2499 | 310.05003 | 310.04976 | 0.27 |
| 31 | 116.1864 | 315.06220 | 315.05839 | 3.80 |
| 32 | 118.1209 | 320.06490 | 320.06823 | -3.33 |
| 33 | 120.4327 | 326.06562 | 326.06524 | 0.38 |
| 34 | 121.9750 | 330.07512 | 330.07494 | 0.18 |

Order of Fit = 11 RMS error of fit = 1.13 mK
Largest absolute error = 3.80 mK at data point no. 31

# INTERPOLATION TABLE

Calibration Report: 562915
Sensor Model: PT-103-AM-70L
Sensor Type: Platinum Resistor

Sales Order: 50282
Serial Number: P15290
Temperature Range: 70.0K to 325K

| Temp (K) | Res. (Ω) | dR/dT (Ω/K) | dlogR/dlogT | Temp (K) | Res. (Ω) | dR/dT (Ω/K) | dlogR/dlogT |
|---|---|---|---|---|---|---|---|
| 70.00 | 17.1080 | 0.41908 | 1.7147 | 215.0 | 76.9486 | 0.39857 | 1.1136 |
| 75.00 | 19.2149 | 0.42330 | 1.6522 | 220.0 | 78.9397 | 0.39786 | 1.1088 |
| 77.35 | 20.2112 | 0.42456 | 1.6248 | 225.0 | 80.9272 | 0.39717 | 1.1042 |
| 80.00 | 21.3377 | 0.42553 | 1.5954 | 230.0 | 82.9113 | 0.39649 | 1.0999 |
| 85.00 | 23.4678 | 0.42634 | 1.5442 | 235.0 | 84.8922 | 0.39583 | 1.0958 |
| 90.00 | 25.5994 | 0.42618 | 1.4983 | 240.0 | 86.8697 | 0.39519 | 1.0918 |
| 95.00 | 27.7286 | 0.42540 | 1.4575 | 245.0 | 88.8441 | 0.39456 | 1.0881 |
| 100.0 | 29.8528 | 0.42424 | 1.4211 | 250.0 | 90.8153 | 0.39394 | 1.0844 |
| 105.0 | 31.9706 | 0.42286 | 1.3888 | 255.0 | 92.7835 | 0.39332 | 1.0810 |
| 110.0 | 34.0812 | 0.42136 | 1.3600 | 260.0 | 94.7485 | 0.39270 | 1.0776 |
| 115.0 | 36.1841 | 0.41981 | 1.3342 | 265.0 | 96.7105 | 0.39208 | 1.0744 |
| 120.0 | 38.2793 | 0.41827 | 1.3112 | 270.0 | 98.6693 | 0.39145 | 1.0712 |
| 125.0 | 40.3669 | 0.41675 | 1.2905 | 273.15 | 99.9017 | 0.39106 | 1.0692 |
| 130.0 | 42.4470 | 0.41529 | 1.2719 | 275.0 | 100.625 | 0.39083 | 1.0681 |
| 135.0 | 44.5199 | 0.41388 | 1.2550 | 280.0 | 102.578 | 0.39020 | 1.0651 |
| 140.0 | 46.5859 | 0.41254 | 1.2398 | 285.0 | 104.527 | 0.38957 | 1.0622 |
| 145.0 | 48.6453 | 0.41126 | 1.2259 | 290.0 | 106.473 | 0.38897 | 1.0594 |
| 150.0 | 50.6986 | 0.41006 | 1.2132 | 295.0 | 108.417 | 0.38838 | 1.0568 |
| 155.0 | 52.7460 | 0.40892 | 1.2017 | 300.0 | 110.357 | 0.38784 | 1.0543 |
| 160.0 | 54.7879 | 0.40784 | 1.1911 | 305.0 | 112.295 | 0.38734 | 1.0520 |
| 165.0 | 56.8246 | 0.40683 | 1.1813 | 310.0 | 114.231 | 0.38687 | 1.0499 |
| 170.0 | 58.8563 | 0.40586 | 1.1723 | 315.0 | 116.164 | 0.38640 | 1.0478 |
| 175.0 | 60.8833 | 0.40494 | 1.1639 | 320.0 | 118.095 | 0.38590 | 1.0457 |
| 180.0 | 62.9057 | 0.40405 | 1.1562 | 325.0 | 120.022 | 0.38521 | 1.0431 |
| 185.0 | 64.9238 | 0.40320 | 1.1489 | | | | |
| 190.0 | 66.9378 | 0.40238 | 1.1421 | | | | |
| 195.0 | 68.9477 | 0.40158 | 1.1358 | | | | |
| 200.0 | 70.9536 | 0.40080 | 1.1297 | | | | |
| 205.0 | 72.9557 | 0.40004 | 1.1241 | | | | |
| 210.0 | 74.9540 | 0.39929 | 1.1187 | | | | |



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# BREAKPOINTS 340 FORMAT

Calibration Report: 562915 Sales Order: 50282
Sensor Model: PT-103-AM-70L Serial Number: P15290
Sensor Type: Platinum Resistor Temperature Range: 70.0K to 325K

Name: PT-103-AM-70L
Serial number: P15290
Format: 3 ;Ohms/Kelvin
Limit: 325.0
Coefficient: 2 ;Positive

Point 1: 3.82000, 30.000
Point 2: 4.23481, 32.000
Point 3: 5.14601, 36.000
Point 4: 6.17000, 40.000
Point 5: 6.72621, 42.000

Point 6: 7.90899, 46.000
Point 7: 9.92364, 52.000
Point 8: 12.1800, 58.000
Point 9: 15.0154, 65.000
Point 10: 17.1047, 70.000

Point 11: 19.6368, 76.000
Point 12: 24.5316, 87.500
Point 13: 28.1560, 96.000
Point 14: 33.4528,108.500
Point 15: 38.7012,121.000

Point 16: 44.1099,134.000
Point 17: 49.8821,148.000
Point 18: 56.0144,163.000
Point 19: 62.5054,179.000
Point 20: 69.3530,196.000

Point 21: 76.5539,214.000
Point 22: 83.9059,232.500
Point 23: 91.4098,251.500
Point 24: 99.0646,271.000
Point 25: 106.672,290.500

Point 26: 115.008,312.000
Point 27: 120.023,325.000
Point 28: 131.616,355.000
Point 29: 148.652,400.000
Point 30: 165.457,445.000

Point 31: 182.035,490.000
Point 32: 198.386,535.000
Point 33: 216.256,585.000
Point 34: 232.106,630.000
Point 35: 247.714,675.000

Point 36: 261.391,715.000
Point 37: 276.566,760.000
Point 38: 289.830,800.000

Note: Breakpoints outside of the calibration range were added from the standard curve. These extra points conform to reduced accuracy specifications and are added as a convenience to the customer.

# BREAKPOINTS 91C/93C/330 FORMAT

Calibration Report: 562915 Sales Order: 50282
Sensor Model: PT-103-AM-70L Serial Number: P15290
Sensor Type: Platinum Resistor Temperature Range: 70.0K to 325K

Interpolation Method: Straight Line
Limit: 325.0 (Kelvin)
Format: 3 (Ohms/Kelvin)
Number of Breakpoints: 29

| No. | Units | Temperature (K) | No. | Units | Temperature (K) |
|---|---|---|---|---|---|
| 1 | 3.82000e-02 | 30.0 | 16 | 0.947680 | 260.0 |
| 2 | 4.23481e-02 | 32.0 | 17 | 1.12313 | 305.0 |
| 3 | 5.14601e-02 | 36.0 | 18 | 1.20020 | 325.0 |
| 4 | 6.17000e-02 | 40.0 | 19 | 1.31616 | 355.0 |
| 5 | 6.72621e-02 | 42.0 | 20 | 1.48652 | 400.0 |
| 6 | 7.90899e-02 | 46.0 | 21 | 1.65457 | 445.0 |
| 7 | 9.92364e-02 | 52.0 | 22 | 1.82035 | 490.0 |
| 8 | 0.121800 | 58.0 | 23 | 1.98387 | 535.0 |
| 9 | 0.150154 | 65.0 | 24 | 2.16256 | 585.0 |
| 10 | 0.170880 | 70.0 | 25 | 2.32106 | 630.0 |
| 11 | 0.234660 | 85.0 | 26 | 2.47714 | 675.0 |
| 12 | 0.340940 | 110.0 | 27 | 2.61391 | 715.0 |
| 13 | 0.466060 | 140.0 | 28 | 2.76566 | 760.0 |
| 14 | 0.609010 | 175.0 | 29 | 2.89830 | 800.0 |
| 15 | 0.769670 | 215.0 | | | |

Note: Breakpoints outside of the calibration range were added from the standard curve. These extra points conform to reduced accuracy specifications and are added as a convenience to the customer.


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