CGEO INTERNATIONAL LIMITED

Model CGEO-CR

Vibrating Wire Crackmeter

Installation Manual

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1. INTRODUCTION

Model CGEO-CR Vibrating Wire Crackmeters are designed to measure movement across joints such as the construction joints in buildings, bridges, pipelines, dams, etc.;coordinating with other different accessories, and also tension cracks in soils and joints in rock and concrete. The gauge is often adopted surface-mounting manner.

The instrument consists of a vibrating wire sensing element in series with a heat treated, stress relieved spring which is connected to the wire at one end and a connecting rod at the other. The unit is fully sealed and operates at pressures of up to 1 Mpa （special requirements can be customized）. As the connecting rod is pulled out from the gage body, the spring is elongated causing an increase in tension which is sensed by the vibrating wire element. The tension in the wire is directly proportional to the extension, hence, the opening of the joint can be determined very accurately by measuring the strain change with the vibrating wire readout box.

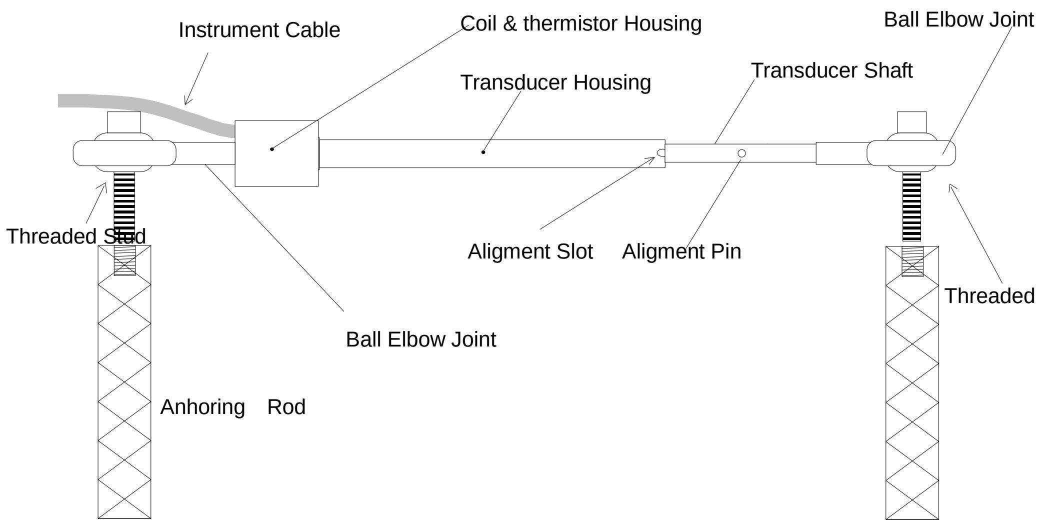

Figure 1 - Model CGEO-CR Vibrating Wire Crackmeter

CAUTION: Do not rotate the shaft of the Crackmeter. This may cause irreparable damage to the instrument. The alignment pin on the transducer shaft and slot on the body serve as a guide for alignment.

2. INSTALLATION

2.1. Preliminary Tests

Upon receipt of the instrument, the gage should be checked for proper operation (including the thermistor). The Crackmeter normally arrives with it's shaft secured at approximately 50% of it's range (see Figure 1). This holds the instrument in tension thereby helping protect it during shipping.

Connect the gage to the Readout to take a reading (see section 3). The reading should be stable and in the range of 4000 to 5000.

Checks of electrical continuity can also be made using an ohmmeter. Resistance between the gage leads should be approximately 180 ohms, ±10 ohms. Remember to add cable resistance when checking (22 AWG stranded copper leads are approximately 14.7Ω/1000' or 48.5Ω/km, multiply by 2 for both directions). Between the green and white should be approximately 3000 ohms at 25 °(see Table B-1), and between any conductor and the shield should exceed 2 megohms.

2.2. Crackmeter Installation

CGEO-CR Model Surface Crackmeter can adopt welding fixture and anchoring manners. You can first weld anchor rod directly on steel member, and then install transducer on anchor rod through the bolts of elbow joint. Another is grouting anchor rod, it adopts a length of twisted-steel connected with the elbow joint. Besides, the factory can also make special forms of installation parts upon requirement.

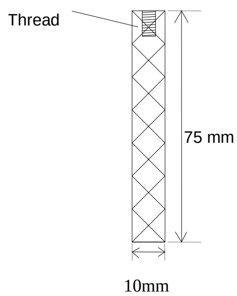

Figure 3 – Standard Grouting Anchor Rod

When setting the gage position using a portable readout (see section 3) use the ranges in Table 2 to determine the proper position.

Mid-Range	Measure Extension	Measure Retraction
4500-5000	2500-3000	6500-7000

Table 2 - Crackmeter Reading Ranges

Note also that the calibration sheet supplied with the Crackmeter shows actual readings at zero, 25%, 50%, 75% and 100% of the range of extension. These readings can be used as a guide to set the Crackmeter in any part of it's range, either in anticipation of closure or opening of the crack. The Crackmeter can be extended until the desired reading (see Section 3 for readout instructions) is obtained and then held in this position while the distance between the anchor points (threaded studs on ball elbow joints, see Figure 1) is measured. This measurement can then serve as a guide for drilling or welding the anchor points.

Caution: ***Do not rotate the shaft of the Crackmeter. This may cause irreparable damage to the instrument. The alignment pin on the transducer shaft and slot on the body serve as a guide for alignment.***

2.2.1. Installation using Weldable Fixtures

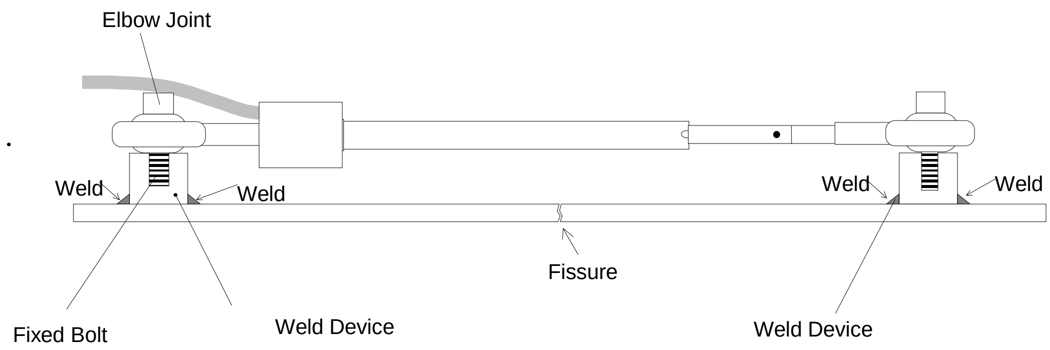

Figure 4 - Installation using Weldable Fixtures

Installation instructions;

1. Determine proper setting distance using figures in Table 1 or the readings on the calibration sheet. Prepare the surface (grinding, sanding, etc.) of the steel around the area of each weldable fixture.
2. Locate fixtures on prepared surfaces, check spacing again and tack weld to member.
3. Remove the nylon tie securing the transducer shaft. Screw the ball stud on each end of the crackmeter into the respective threaded holes on the fixtures. Remove the cotter pins from the end of each ball elbow joint and tighten the ball using a regular blade screwdriver. Re-install the cotter pins to secure the ball locking screw.
4. Check the reading with a portable readout. Use Table 2 or the readings on the calibration sheet to check the position. Installation complete.

Note: Under normal circumstance, the installation of transducer itself should be after the welding of weldable fixture, after completion of transducer installation, prohibited is any welding treatment of weldable fixture, or it may cause transducer permanent damage.CGEO will not response for any warranty and liability of any damage caused by this. Even if performing welding under protection cover installation, you must do it in same end of transducer grounding, simultaneously avoid intentionally or un-intentionally touching striking arc, that is, ensure welding current not through transducer from beginning to end. You can consult the factory for the relevant manner.

2.2.2. Installation using Groutable Anchors

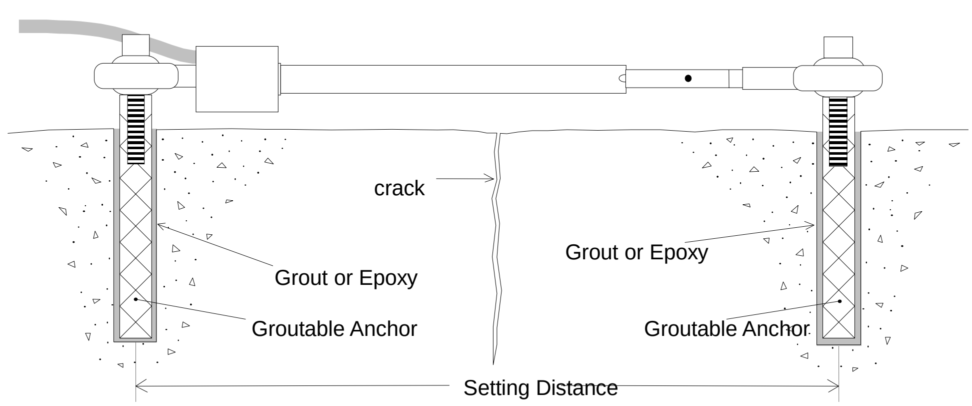

Figure 5 - Installation using Groutable Anchors

Installation instructions;

1. Determine proper setting distance using figures from Table 1 or the readings on the calibration sheet. Using a hammer drill or other suitable equipment, drill two ½" holes approximately 3" deep at the proper locations. Shorter holes may be drilled if the anchors are cut down accordingly.

2. Assemble the Crackmeter with anchors attached. If installing the instrument at the mid-range position, leave the nylon tie installed (see Figure 1) that secures the transducer shaft. Fill the holes with grout or epoxy and push the anchors in until the tops are flush with the surface. For holes drilled overhead use a quick setting grout or epoxy.

3. Secure the instrument after the grout or epoxy has set. Remove the cotter pins from the end of each ball elbow joint and tighten the ball using a regular blade screwdriver. Re-install the cotter pins to secure the ball locking screw. Remove the nylon tie.

4. Check the reading with a portable readout. Use Table 2 or the readings on the calibration sheet to check the position. Installation complete.

2.2.3. Installation using Machine Bolt Expansion Anchors

The Bolt Expansion Anchor is needed to customize, applied to quick installation or unable to install groutable anchor. The user self can also purchase inner expansion (inner explosion type) bolt, make a M6 hole in bolt using for the connection of elbow joint.

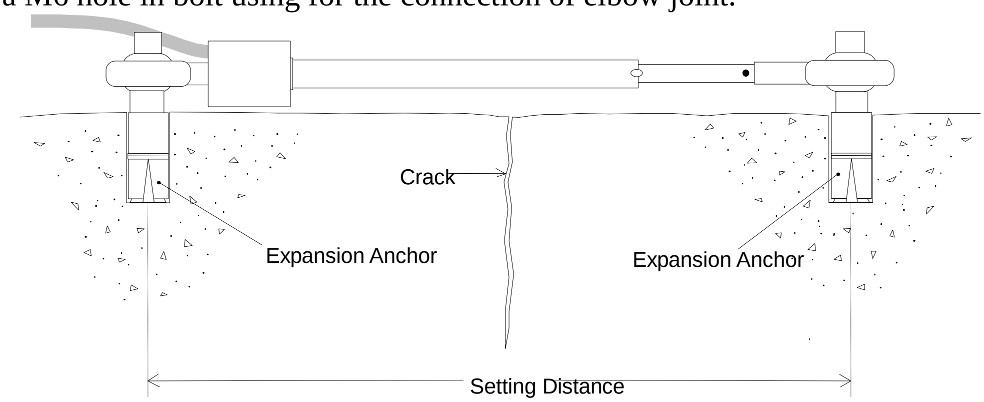

Figure 6 - Installation using Machine Bolt Expansion Anchors

Installation instructions;

1. Determine proper setting distance using figures from Table 1 or the readings on the calibration sheet. Using a hammer drill or other suitable equipment, drill two ½" holes approximately 2" deep at the proper locations.
2. Insert the expansion anchors with the threaded ends down into the hole, and tighten.
3. Remove the nylon tie securing the transducer shaft. Screw the ball stud on each end of the crackmeter into the respective threaded holes in the anchors. Remove the cotter pins from the end of each ball elbow joint and tighten the ball using a regular blade screwdriver. Re-install the cotter pins to secure the ball locking screw.
4. Check the reading with a portable readout. Use Table 2 or the readings on the calibration sheet to check the position. Installation completes.

2.3. Cable Installation

The cable should be routed in such a way so as to minimize the possibility of damage due to moving equipment, debris or other causes.

Cables may be spliced to lengthen them, without affecting gage readings. Always waterproof the splice completely, preferably using an epoxy based splice kit such the dedicated cable heat shrinkable connector kit. These kits are available from the factory. quick cable connector also can be used.

2.4. Electrical Noise

Care should be exercised when installing instrument cables to keep them as far away as possible from sources of electrical interference such as power lines, generators, motors, transformers, arc welders, etc. Cables should never be buried or run with AC power lines. The instrument cables will pick up the 50 or 60 Hz (or other frequency) noise from the power cable and this will likely cause a problem obtaining a stable reading. Contact the factory concerning filtering options available for use with the CGEO dataloggers and readouts should difficulties arise.

2.5. Lightning Protection

The Vibrating Wire Crackmeter, unlike numerous other types of instrumentation available from CGEO, do not have any integral lightning protection components, i.e. transzorbs or plasma surge arrestors. Usually this is not a problem however, if the instrument cable is exposed, it may be appropriate to install lightning protection components, as the transient could travel down the cable to the gage and possibly destroy it.

Note the following suggestions;

- If the gage is connected to a terminal box or multiplexer components such as plasma surge arrestors (spark gaps) may be installed in the terminal box/multiplexer to provide a measure of transient protection. Terminal boxes and multiplexers available from CGEO provide locations for installation of these components.
- Lighting arrestor boards and enclosures are available from CGEO that install near the instrument. The enclosure has a removable top so, in the event the protection board (LAB-3) is damaged, the user may service the components (or replace the board). A connection is made between this enclosure and earth ground to facilitate the passing of transients away from the gage. See Figure 7. Consult the factory for additional information on these or alternate lightning protection schemes.

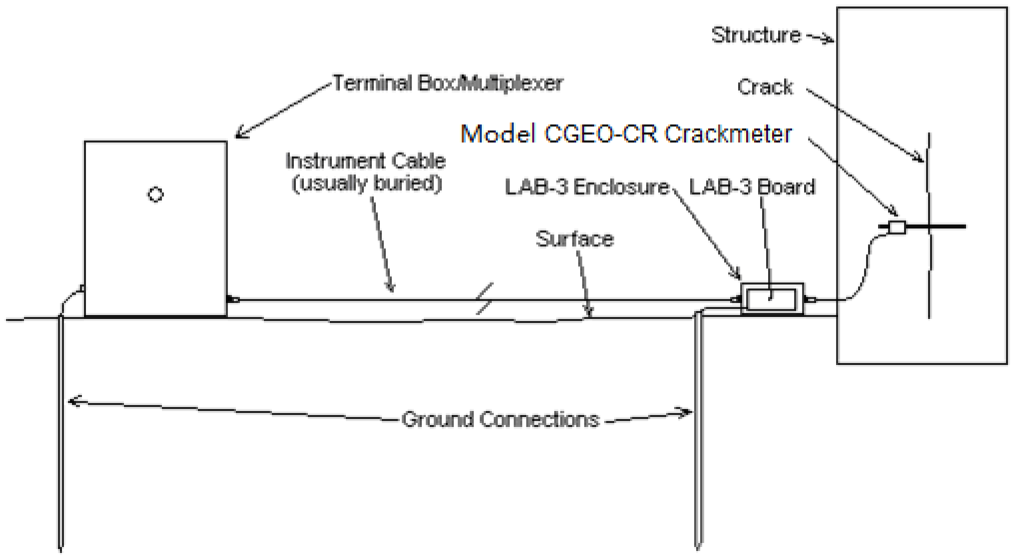

Figure 7 - Lightning Protection Scheme

3. TAKING READINGS

The following three sections describe how to take readings using one of readouts available from CGEO.

3.1. Operation of the CGEO-PR-VW Readout Box

CGEO-PR-VW can be used for Surface Crackmeter measurement. Connect the Readout using the flying leads or in the case of a terminal station, with a connector. The red and black clips are for the vibrating wire gage, the white and green clips are for the thermistor and the blue for the shield drain wire.

1. Turn the display selector to position "B" . Readout is in digits.

2. Turn the unit on and a reading will appear in the front display window. The last digit may change one or two digits while reading. Record the value displayed. If no reading displays or the reading is unstable see section 5 for troubleshooting suggestions. The thermistor will be read and output directly in degrees centigrade.

3. The unit will automatically turn itself off after approximately 15 minutes to conserve power. Details please see the CGEO-PR-VW Instruction Manual.

3.2. Measuring Temperatures

Each Vibrating Wire Crackmeter is equipped with a thermistor for reading temperature. The thermistor gives a varying resistance output as the temperature changes. Usually the white and green leads are connected to the internal thermistor.

1. Connect an ohmmeter to the two thermistor leads coming from the Crackmeter. (Since the resistance changes with temperature are so large, the effect of cable resistance is usually insignificant.)

2. Look up the temperature for the measured resistance in Table B-1. Alternately the temperature could be calculated using Equation B-1.

Note: The CGEO-PR-VW readout box will read the thermistor and display temperature in °C automatically.

4. DATA REDUCTION

4.1. Deformation Calculation

The basic units utilized by CGEO for measurement and reduction of data from Vibrating Wire Crackmeters are "digits". Calculation of digits is based on the following equation;

$$\text{Digits} = \frac{Hz^2}{1000}$$

Equation 1 - Digits Calculation

To convert digits to deformation the following equation applies;

$$\mathbf{D_{uncorrected} = (R_1 - R_0) \times G}$$

Equation 2 - Deformation Calculation

Where; R_1 is the current reading.
R_0 is the initial reading, usually obtained at installation
G is the calibration factor, unit as mm/digit, given in calibration sheet.

For example, the initial reading R_0, at installation of a crackmeter is 2500 digits. The current reading, R_1, is 6000. The calibration factor is 0.00356 mm/digit. The deformation change is;

$$D_{uncorrected} = (6000 - 2500) \times 0.00356 = +12.446 \text{ mm}$$

Note that increasing readings (digits) indicate increasing extension.
When the environment temperature changes big(over 10℃)，it needs temperature correction and it is performed according to calculation formula supplied in the factory calibration sheet. Please see table 8 and next chapter.

VIBRATING WIRE INSTRUMENT CALIBRATION CERTIFICATE

Model:CGEO-CR-50T **Serial Number： 081802**

Temperature：20 ℃ **Humidity： 32%RH**

Testing Result

Range：(0---50)mm
Reader box: CGEO-PR-VW

Applied Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Gage Reading 3rd Cycle	Average Gage Reading	Error Linear (F.S)	Error Polynomial (F.S)
0.0	2441.8	2440.6	2441.5	2441.3	-0.20%	-0.01%
10.0	3479.3	3479.7	3479.0	3479.3	0.06%	0.02%
20.0	4509.8	4508.1	4509.5	4509.1	0.16%	0.01%
30.0	5533.0	5532.3	5532.7	5532.7	0.13%	-0.02%
40.0	6552.0	6551.7	6551.9	6551.9	0.03%	-0.01%
50.0	7566.4	7566.3	7566.1	7566.3	-0.18%	0.01%
/	/	/	/	/	/	/

Calculated Displacement:

Linear， $L(mm) = G(R_1 - R_0) + K(T_1 - T_0)$

Polynomial， $L(mm) = AR_1^2 + BR_1 + C + K(T_1 - T_0)$

Linear Gage Factor： G = 0.00975839 mm/Digit

(mm) Polynomial Gage Factors： A = 0.000000026645441378193

B = 0.0094917094213891

C = -23.33732890100

Thermal Factor： K = 0.00853859 mm/℃

R_0 **……….Original Reading**

T_0 **……….Original Tempera**

Hereinafter Blank

Figure 8 - Typical Crackmeter Calibration Sheet

4.2. Temperature Correction

The Model CGEO-CR Vibrating Wire Crackmeters have a very small coefficient of thermal expansion so in many cases correction is not necessary. However, if maximum accuracy is desired or the temperature changes are extreme (>10 °C) corrections may be applied. The temperature coefficient of the mass or member to which the Crackmeter is attached should also be taken into account. By correcting the transducer for temperature changes the temperature coefficient of the mass or member may be distinguished. The following equation applies;

$$D_{corrected} = (R_1 - R_0) \times G + ((T_1 - T_0) \times K$$

Equation 3 - Thermally Corrected Deformation Calculation

Where; R_1 is the current reading.
R_0 is the initial reading.
G is the calibration factor.
T_1 is the current temperature.
T_0 is the initial temperature.
K is the thermal coefficient (see calibration sheet).

Consider the following example using a Model J2-25 mm Crackmeter;

$R_0 = 4773$ *digits*

$R_1 = 4589$ *digits*

$T_0 = 20.3\ °C$

$T_1 = 32.9\ °C$

$G = 0.00555$ *mm/digit*

$K = (((4589 \times 0.000301) + 0.911) \times 0.00555) = 0.0127$

$D_{corrected} = ((R_1 - R_0) \times C) + (((T_1 - T_0) \times K)$

$D_{corrected} = ((4589 - 4773) \times 0.00555) + ((32.9 - 20.3) \times 0.0127)$

$D_{corrected} = (-184 \times 0.00555) + 0.160$

$D_{corrected} = -1.021 + 0.160$

$D_{corrected} = -0.861$ *mm*

As can be seen from the above example, the corrections for temperature change are very small and can usually be ignored.

4.3. Environmental Factors

Since the purpose of the crackmeter installation is to monitor site conditions, factors which may affect these conditions should always be observed and recorded. Seemingly minor effects may have a real influence on the behavior of the structure being monitored and may give an early indication of potential problems. Some of these factors include, but are not limited to: blasting, rainfall, tidal levels, excavation and fill levels and sequences, traffic, temperature and barometric changes, changes in personnel, nearby construction activities, seasonal changes, etc.

5. TROUBLESHOOTING

Maintenance and troubleshooting of CGEO Vibrating Wire Crackmeters is confined to periodic checks of cable connections and maintenance of terminals. The transducers themselves are sealed and cannot be opened for inspection. However, note the following problems and possible solutions should difficulties arise. Consult the factory for additional troubleshooting help.

Symptom: Crackmeter Readings are Unstable

✓ Is the readout box position set correctly? If using a datalogger to record readings automatically are the swept frequency excitation settings correct?

- ✓ Is the transducer shaft positioned outside the specified range (either extension or retraction) of the instrument? Note that when the transducer shaft is fully retracted with the alignment pin inside the alignment slot (Figure 1) the readings will likely be unstable because the vibrating wire is now under-tensioned.

- ✓ Is there a source of electrical noise nearby? Most probable sources of electrical noise are motors, generators and antennas.

Symptom: Crackmeter Fails to Read

- ✓ Is the cable cut or crushed? This can be checked with an ohmmeter. Nominal resistance between the two transducer leads (usually red and black leads) is 180Ω, ±10Ω. Remember to add cable resistance when checking (22 AWG stranded copper leads are approximately 14.7Ω /1000' or 48.5Ω/km). If the resistance reads infinite, or very high (>1 megohm), a cut wire must be suspected. If the resistance reads very low (<100Ω) a short in the cable is likely. Splicing kits and instructions are available from the factory to repair broken or shorted cables. Consult the factory for additional information.

- ✓ Does the readout or datalogger work with another transducer? If not the readout or datalogger may be malfunctioning.

APPENDIX A - THERMISTOR TEMPERATURE DERIVATION

Thermistor Type: YSI 44005, Dale #1C3001-B3, Alpha #13A3001-B3

Resistance to Temperature Equation:

$$T = \frac{1}{A + B(LnR) + C(LnR)^3} - 273.2$$

Equation B-1 Convert Thermistor Resistance to Temperature

Where: T = Temperature in °C.
LnR = Natural Log of Thermistor Resistance
A = 1.4051×10^{-3} (coefficients calculated over the −50 to +150° C. span)
B = 2.369×10^{-4}
C = 1.019×10^{-7}

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	16.60K	-10	2417	+30	525.4	+70	153.2	+110
187.3K	-49	15.72K	-9	2317	31	507.8	71	149.0	111
174.5K	-48	14.90K	-8	2221	32	490.9	72	145.0	112
162.7K	-47	14.12K	-7	2130	33	474.7	73	141.1	113
151.7K	-46	13.39K	-6	2042	34	459.0	74	137.2	114
141.6K	-45	12.70K	-5	1959	35	444.0	75	133.6	115
132.2K	-44	12.05K	-4	1880	36	429.5	76	130.0	116
123.5K	-43	11.44K	-3	1805	37	415.6	77	126.5	117
115.4K	-42	10.86K	-2	1733	38	402.2	78	123.2	118
107.9K	-41	10.31K	-1	1664	39	389.3	79	119.9	119
101.0K	-40	9796	0	1598	40	376.9	80	116.8	120
94.48K	-39	9310	+1	1535	41	364.9	81	113.8	121
88.46K	-38	8851	2	1475	42	353.4	82	110.8	122
82.87K	-37	8417	3	1418	43	342.2	83	107.9	123
77.66K	-36	8006	4	1363	44	331.5	84	105.2	124
72.81K	-35	7618	5	1310	45	321.2	85	102.5	125
68.30K	-34	7252	6	1260	46	311.3	86	99.9	126
64.09K	-33	6905	7	1212	47	301.7	87	97.3	127
60.17K	-32	6576	8	1167	48	292.4	88	94.9	128
56.51K	-31	6265	9	1123	49	283.5	89	92.5	129
53.10K	-30	5971	10	1081	50	274.9	90	90.2	130
49.91K	-29	5692	11	1040	51	266.6	91	87.9	131
46.94K	-28	5427	12	1002	52	258.6	92	85.7	132
44.16K	-27	5177	13	965.0	53	250.9	93	83.6	133
41.56K	-26	4939	14	929.6	54	243.4	94	81.6	134
39.13K	-25	4714	15	895.8	55	236.2	95	79.6	135
36.86K	-24	4500	16	863.3	56	229.3	96	77.6	136
34.73K	-23	4297	17	832.2	57	222.6	97	75.8	137
32.74K	-22	4105	18	802.3	58	216.1	98	73.9	138
30.87K	-21	3922	19	773.7	59	209.8	99	72.2	139
29.13K	-20	3748	20	746.3	60	203.8	100	70.4	140
27.49K	-19	3583	21	719.9	61	197.9	101	68.8	141
25.95K	-18	3426	22	694.7	62	192.2	102	67.1	142
24.51K	-17	3277	23	670.4	63	186.8	103	65.5	143
23.16K	-16	3135	24	647.1	64	181.5	104	64.0	144
21.89K	-15	3000	25	624.7	65	176.4	105	62.5	145
20.70K	-14	2872	26	603.3	66	171.4	106	61.1	146
19.58K	-13	2750	27	582.6	67	166.7	107	59.6	147
18.52K	-12	2633	28	562.8	68	162.0	108	58.3	148
17.53K	-11	2523	29	543.7	69	157.6	109	56.8	149
								55.6	150

Table A-1 Thermistor Resistance versus Temperature