Model 4422

Vibrating Wire

Monument (Micro) Crackmeter

Instruction Manual

GEOKON®

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1. INTRODUCTION

The GEOKON Model 4422 Monument (Micro) Crackmeter is designed to measure movement across joints and cracks in monuments. The small size is designed to render the crackmeter as unobtrusive as possible. The shaft of the Monument Crackmeter has three small holes drilled in it. A metal pin is supplied for insertion inside one of these holes. These holes and the metal pin are designed to assist the user in selecting the range of the crackmeter so that it can be set to measure mainly tensions, mainly compressions, or both, depending on which hole the metal pin is inserted. The maximum range is four mm.

The instrument consists of a vibrating wire sensing element in series with a heat treated, stress relieved spring, which is connected to the vibrating wire at one end, and to a connecting rod at the other. As the connecting rod is pulled out from the gauge body, the spring is elongated, causing an increase in tension in the vibrating wire. The increase in tension (strain) of the wire is directly proportional to the extension of the connecting rod. This change in strain allows the Monument Crackmeter to measure the opening of a joint very accurately.

Monument Crackmeters are designed to be read by one of the various readout boxes available from GEOKON.

2. INSTALLATION

2.1 PRELIMINARY TESTS

Sensors are shipped with a shipping spacer pin installed, securing the sensor at half range. This maintains tension to prevent damage during transportation.

GEOKON recommends that each sensor is function tested before installing in the field. To perform this preliminary check complete the following steps:

Important! Care should be taken to not rotate the sensor shaft more than 180 degrees. This may cause irreparable damage to the instrument. Never extend the sensor beyond its working range.

1. Connect the sensor to a readout. This could be a portable, handheld readout or the system that will be used in the final installation.
2. The sensor should have a strong, stable signal, reading approximately 4500 digits with the pin installed. Gently pull on the ends of the sensor, the readings should be stable and in the range of 2500 to 6000 digits.

Important! Do not extend the push rod so that the full range of the sensor as indicted in the supplied calibration sheet is exceeded.

3. Check electrical continuity using an ohmmeter. Resistance between the gauge leads (usually red and black) should be approximately 50 Ω. Remember to add cable resistance, which is approximately 48.5Ω per km (14.7Ω per 1000 feet) of 22 AWG stranded copper leads at 20 °C. Multiply this factor by two to account for both directions. Resistance between thermistor leads (usually green and white) will vary based on temperature (see Appendix B). Resistance between any conductor and the shield should exceed two megaohms.

2.2 SENSOR INSTALLATION

The sensor is provided with threaded rods that can be either grouted in short drill holes or epoxied to the surface. It will normally be found more convenient to fix the cable in place before the sensor is attached.

The sensor may be installed at its midrange position by leaving the metal pin in (see Figure 1 and Figure 2 in the following sub-sections) or the pin may be removed, allowing the initial gauge reading to be set for the anticipated direction of movement. When setting the gauge position using a portable readout, use the reading ranges in Table 1 to determine the proper position.

Approximate Midrange Reading	Approximate Reading to Measure Extensions	Approximate. Reading to Measure Compression
4000-4500	2500-3000	5500-6000

TABLE 1: *Model 4422 Reading Ranges*

2.2.1 GROUTABLE ANCHOR MOUNTING

For the standard range crackmeter (4 mm), drill two 9 mm (3/8") diameter holes, spaced 114.3mm (4.5") apart, to a depth of 25 mm (1"). A drilling template (Model 4422-3) is also available for purchase. To use the drilling template, drill one hole then place a slightly smaller drill in the hole and use the spacer bar to locate the second hole.

Screw the two stainless steel studs onto the threaded rods. Fill the drill holes with epoxy or quick setting cement, and push the studs into the grout or epoxy. If installing at midrange, keep the metal spacer pin in place until the grout or epoxy has hardened, after which the metal pin can be removed.

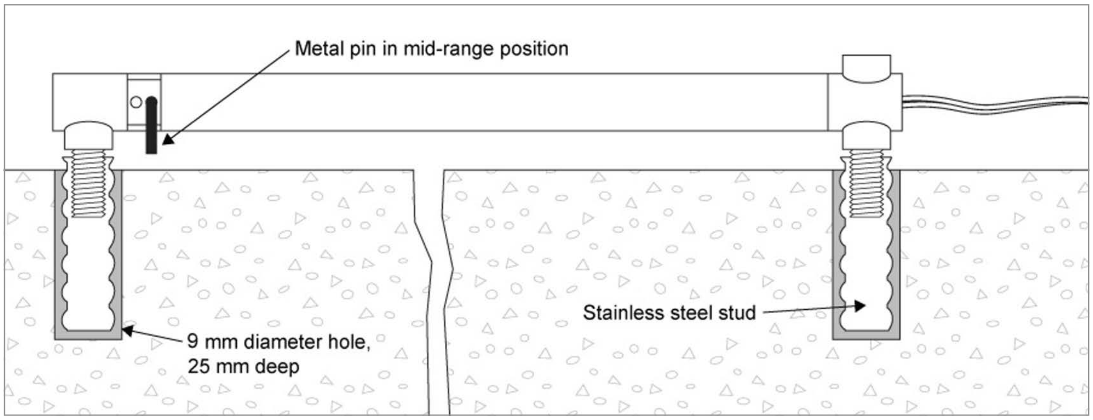

FIGURE 1: *Groutable Anchor Mounting*

2.2.2 SURFACE MOUNTING

For surface mounting, two stainless steel feet are supplied. Screw the steel feet on to the threaded rods of the sensor. Prepare some quick setting epoxy and apply to both the surface of the monument and to the surface of the stainless steel feet. Press the feet down on to the monument surface and hold in place until the epoxy sets up. If installing at midrange, keep the metal spacer pin in place until the epoxy has hardened, after which the metal pin can be removed.

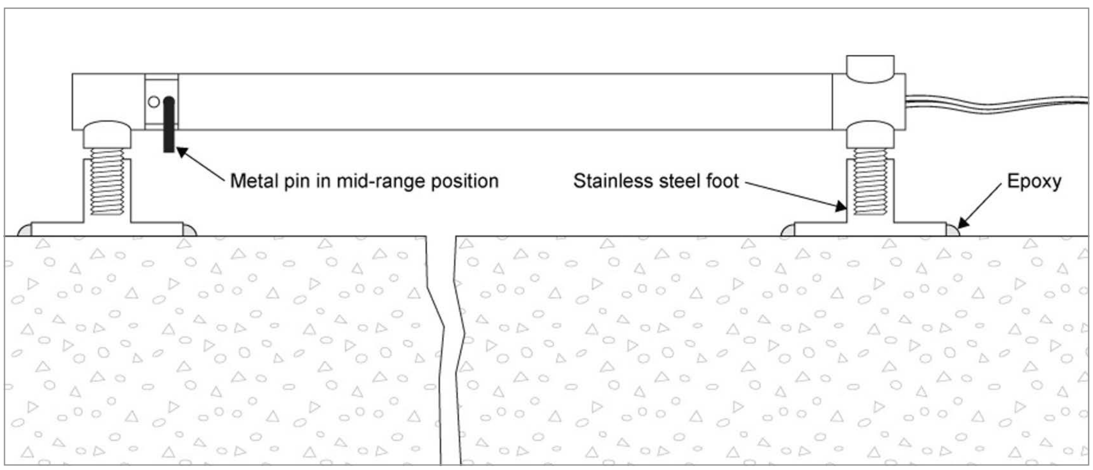

FIGURE 2: *Surface Mounting*

2.3 INITIAL READINGS

Initial readings must be taken and carefully recorded along with the temperature at the time of installation. These readings serve as a reference for subsequent deformation calculations.

2.4 CABLE AND CONNECTOR PROTECTION

The cable should be protected from accidental damage caused by moving equipment or debris. This is best accomplished by routing the cable through flexible conduit (available from GEOKON). The conduit can be connected via conduit bulkhead connectors to the cover plates. The GEOKON cover plates have a stamped knockout, which provides a hole for the conduit connector.

Because the vibrating wire output signal is a frequency rather than a current or voltage, cable splicing has no ill effects. The cable used for making splices should be a high-quality, twisted pair type, with 100% shielding, and an integral shield drain wire. **It is very important that the shield drain wires be spliced together.** Always maintain polarity when possible by connecting color to color.

Splice kits recommended by GEOKON incorporate casts that are placed around the splice and are then filled with epoxy to waterproof the connections. When properly made, this type of splice is equal or superior to the cable in strength and electrical properties. Contact GEOKON for splicing materials and additional cable splicing instructions.

Install instrument cables 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. Doing so will cause the instrument cables to pick up the frequency noise from the power cable, and this will likely make obtaining a stable reading difficult.

2.5 LIGHTNING PROTECTION

In settings where lightning strikes are a concern, GEOKON offers the Model 4999-12L/LE Surge Protection Module:

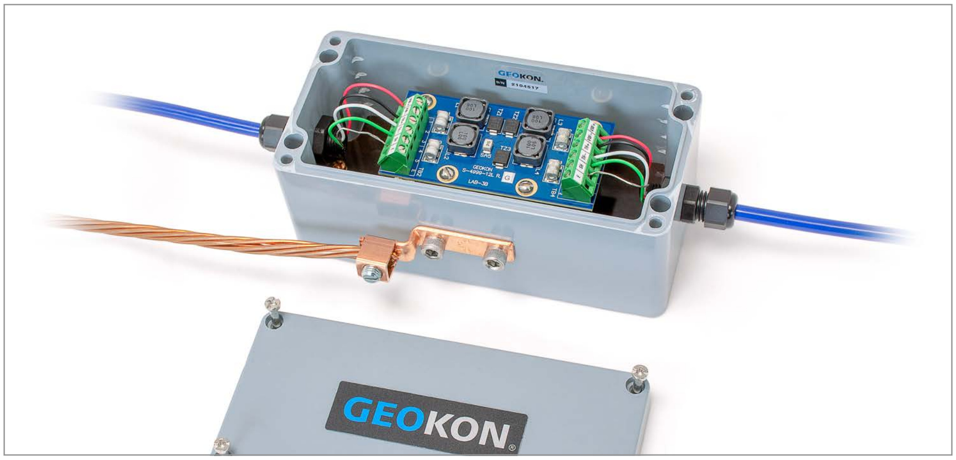

FIGURE 3: *Model 4999-12L/LE*

The module features surge protection circuitry that can be replaced in the event that it is damaged by a lightning strike. The Module is installed between a sensor and the data logger or terminal box it is connected to (see Figure 4). Consult the Model 4999-12L/LE Instruction Manual (geokon.com/4999-12L/E) for additional information.

Additional lightning protection measures available include:

- Terminal boxes available from GEOKON can be ordered with lightning protection built in. The terminal board used to make the sensor connections has provision for the installation of plasma surge arrestors. Lightning Arrestor Boards (Model 4999-12L) can also be incorporated into the terminal box. The terminal box must be connected to an earth ground for these levels of protection to be effective.

- Plasma surge arrestors can be epoxied into the instrument cable, close to the transducer. A ground strap then connects the surge arrestor to an earth ground, such as a grounding stake or the rebar itself.

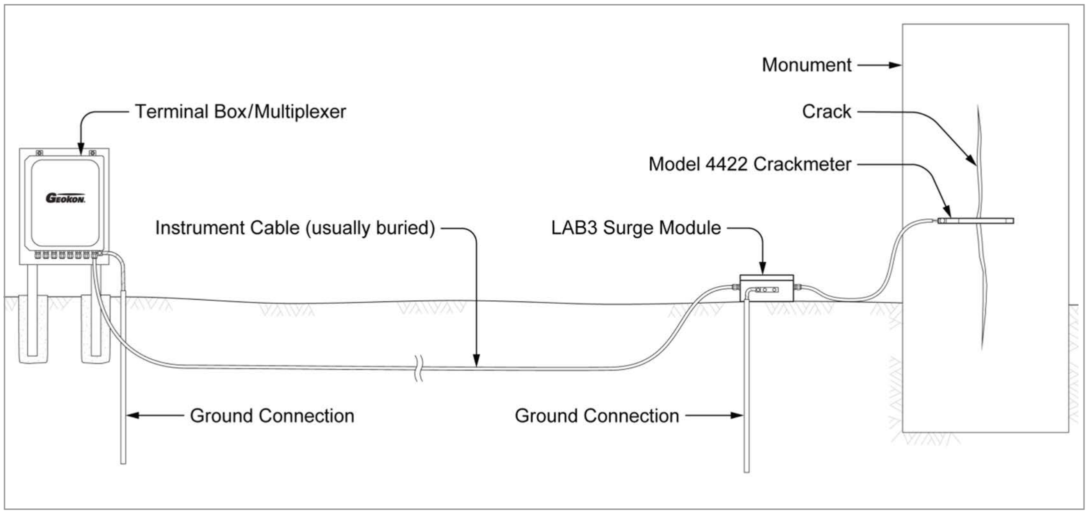

FIGURE 4: *Lightning Protection Scheme*

3. TAKING READINGS

The most important reading is the first reading; it is the base reading to which all subsequent readings will be compared. Conditions should be noted at the time of all readings, especially during curing, e.g., temperature, time after placement, local conditions, etc.

3.1 COMPATIBLE READOUTS AND DATA LOGGERS

GEOKON can provide several readout and data logger options. Devices compatible with this product are listed below. For further details and instruction consult the corresponding Manual(s) at geokon.com/Readouts and geokon.com/Dataloggers.

DIGITAL READOUTS:

- **GK-404**

  The Model GK-404 VW Readout is a portable, low-power, hand-held unit capable of running for more than 20 hours continuously on two AA batteries. It is designed for the readout of all GEOKON Vibrating Wire (VW) instruments, and can display the reading in digits, frequency (Hz), period (µs), or microstrain (µε). The GK-404 displays the temperature of the sensor (embedded thermistor) with a resolution of 0.1 °C.

- **GK-406**

  The Model GK-406 is a field-ready device able to quickly measure a sensor, save data, and communicate results with custom PDF reports and spreadsheet output. Measurements are geo-located with the integrated GPS allowing the GK-406 to verify locations and lead the user to the sensor locations. The large color display and VSPECT™ technology produce the best measurement possible both in the field and in the office.

DATA LOGGERS:

- **GeoNet Series**

  The GeoNet Data Logger series is designed to collect and transfer data from vibrating wire, RS-485, and analog instruments. GeoNet offers a wide range of telemetry options, including LoRa, cellular, Wi-fi, satellite, and local. Data loggers can work together to operate in a network configuration, or be used separately as standalone units. GeoNet devices arrive from the factory ready for deployment and may commence with data acquisition in minutes.

  Data is transferred to a secure cloud-based storage platform where it can be accessed through the GEOKON OpenAPI. Industry leading data visualization software, such as the free GEOKON Agent Software, can be used with the OpenAPI for data viewing and reporting. Data loggers without network capabilities are also available.

- **8600 Series**

  The Model 8600 Series Data Logger is designed to support the reading of a large number of GEOKON instruments for various unattended data collection applications using GEOKON Model 8032 Multiplexers. Weatherproof packaging allows the unit to be installed in field environments where inhospitable conditions prevail. The Nema 4X enclosure also has a provision for locking to limit access to responsible field personnel.

3.2 MODEL 4999 TERMINAL BOXES

Terminal boxes with sealed cable entries are available from GEOKON. These allow many sensors to be terminated at one location with complete protection of the lead wires. The interior panel of the terminal box can have built-in jacks or a single connection with a rotary position selector switch.

Terminal Boxes make it easy to manually connect a Readout Box (GK-404 or GK-406). The rotary switch is used to select which “channel” or sensor is being read by the Readout Box.

For further details and instruction consult the Model 4999 Instruction Manual (geokon.com/4999).

3.3 MEASURING TEMPERATURES

All GEOKON vibrating wire sensors are equipped with a thermistor for reading temperature. The thermistor gives a varying resistance output as the temperature changes. The white and green leads of the sensor cable are normally connected to the internal thermistor.

The GK-404 and GK-406 readouts will read the thermistor and display the temperature in degrees Celsius.

USING AN OHMMETER TO READ TEMPERATURES:

Connect an ohmmeter to the green and white thermistor leads coming from the sensor. Since the resistance changes with temperature are large, the effect of cable resistance is usually insignificant. For long cables a correction can be applied equal to approximately 48.5 Ω per km (14.7 Ω per 1000') at 20 °C. Multiply these factors by two to account for both directions.

Look up the temperature for the measured resistance in Appendix B.

4. DATA REDUCTION

4.1 DATA CALCULATION

The basic units utilized by GEOKON for measurement and reduction of data from this sensor are digits. The calculation of digits is based on the following equation:

$$\text{digits} = \frac{\text{Hz}^2}{1000} \quad \text{or} \quad \text{digits} = \left(\frac{1}{\text{Period}}\right)^2 \times 10^{-3}$$

EQUATION 1: *Digits Calculation*

In typical installations the linear calculation is more than sufficient. However, if utmost accuracy is desired, the polynomial calculation can be used. Refer to the applicable section below.

4.1.1 LINEAR CALCULATION

To convert digits to displacement the following equation applies:

$$D = G(R_1 - R_0)$$

EQUATION 2: *Linear Displacement Calculation*

Where:
G = The gauge factor found on the calibration report, usually in terms of millimeters or inches per digit.

R_1 = The current reading in digits.
R_0 = The initial field zero reading in digits.

EXAMPLE:

The initial reading (R_0) at installation of a sensor is 4000 digits. The current reading (R_1) is 5000 digits. The calibration factor (G) is 0.001077 mm/digit. The displacement change is:

$$D = (5000 - 4000) \times 0.001077$$

$$D = 1.077 \text{ mm}$$

Note that increasing (positive) readings indicate increasing extension.

4.1.2 POLYNOMIAL CALCULATION

To convert digits to displacement using the polynomial expression the following equation applies:

$$D = AR_1^2 + BR_1 + C$$

EQUATION 3: *Polynomial Displacement Calculation*

Where:
R_1 = The current reading in digits.
A, B = The polynomial gauge factors found on the calibration report.
C = The polynomial gauge factor that needs to be calculated (see below).

To perform the polynomial calculation, gauge factor “C” must be calculated first. This is done by using the equation above, but replacing “D” with a value of zero, and “R_1” with the value of “R_0”.

$$0 = AR_0^2 + BR_0 + C$$

EQUATION 4: *Calculation for Polynomial Gauge Factor “C”*

Where:
R_0 = The initial field zero reading in digits.
A, B = The polynomial gauge factors found on the calibration report.

The calculated “C” can then be used in Equation 3 to find the precise value of displacement (D).

EXAMPLE:

The given polynomial gauge factors on the calibration are:

A = 8.82487E-09

B = 0.001007

The initial reading (R_0) at installation of a sensor is 4000 digits. The current reading (R_1) is 5000 digits.

First, the gauge factor “C” must be calculated:

$$0 = AR_0^2 + BR_0 + C$$

$$0 = 8.82487\times10^{-9} \times 4000^2 + 0.001007 \times 4000 + C$$

$$0 = 4.169 + C$$

$$C = -4.169$$

The displacement change is:

$$D = AR_1^2 + BR_1 + C$$

$$D = 8.82487\times10^{-9} \times 5000^2 + 0.001007 \times 5000 + (-4.169)$$

$$D = 1.087 \text{ mm}$$

Note that increasing (positive) readings indicate increasing extension.

4.2 OPTIONAL CALCULATIONS

4.2.1 TEMPERATURE CORRECTION

The sensor has a very small coefficient of thermal expansion so in most cases correction is not necessary. However, if maximum accuracy is desired or the temperature changes are extreme (>10° C) corrections may be applied. By correcting the sensor for temperature changes the deformation of the mass may be distinguished. The following thermal correction equation is performed, then afterwards is added to the displacement calculation (Equation 2 or Equation 3):

$$T_{Correction} = K(T_1 - T_0)$$

EQUATION 5: *Thermal Correction for Displacement*

Where:
K = The thermal factor that needs to be calculated (see below).
T_1 = The current temperature reading in °C.
T_0 = The initial field temperature reading in °C.

Tests have determined that the thermal coefficient “K” changes with the position of the sensor shaft. Hence, the first step in the temperature correction process is determination of the proper thermal coefficient based on the following equation:

$$K = ((R_1 \times M) + B) \times G$$

EQUATION 6: *Calculation for Thermal Factor "K"*

Where:
R_1 = The current readings in digits.
M = The multiplier, from the table below.
B = The constant, from the table below.
G = The gauge factor found on the calibration report, usually in terms of millimeters or inches per digit.

Table 2 gives the multiplier and constant values used in Equation 6.

Multiplier (M)	Constant (B)
0.000281	0.813372

TABLE 2: *Thermal Coefficient Constant Values*

EXAMPLE:

T_0 = 20.3 °C.
T_1 = 32.9 °C.
R_1 = 5000 digits
G = 0.001077 mm/digit

First, calculate the thermal coefficient (K):

$$K = ((R_1 \times M) + B) \times G$$

$$K = ((5000 \times 0.000281) + 0.813372) \times 0.001077 = 0.0024$$

Calculate the thermal correction:

$$T_{Correction} = K(T_1 - T_0)$$

$$T_{Correction} = 0.0024(32.9 - 20.3) = 0.0302$$

Add this value to the displacement calculated using Equation 2 or Equation 3 to find the thermal corrected displacement.

4.2.2 ENGINEERING UNITS CONVERSION

To convert to a different engineering unit, take the result from data calculation (after other optional calculations have been completed, if applicable) and multiply it by the appropriate conversion multiplier from Table 3.

		CONVERT FROM				
		Inches	**Feet**	**Millimeters**	**Centimeters**	**Meters**
CONVERT TO	**Inches**	1	12	0.03937	0.3937	39.37
	Feet	0.0833	1	0.003281	0.03281	3.281
	Millimeters	25.4	304.8	1	10	1000
	Centimeters	2.54	30.48	0.10	1	100
	Meters	0.0254	0.3048	0.001	0.01	1

TABLE 3: *Engineering Units Conversion Multipliers*

4.3 ENVIRONMENTAL FACTORS

Since the purpose of the 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 is confined to periodic checks of cable connections and maintenance of terminals. Once installed, the sensor is usually inaccessible and remedial action is limited.

Should difficulties arise, consult the following list of problems and possible solutions. For additional troubleshooting and support visit geokon.com/Technical-Support.

SYMPTOM: THERMISTOR RESISTANCE IS TOO HIGH

- ☐ Check for an open circuit. Check all connections, terminals, and plugs. If a cut is in the cable, splice according to instructions in Section 2.4.

SYMPTOM: THERMISTOR RESISTANCE IS TOO LOW

- ☐ Check for a short circuit. Check all connections, terminals, and plugs. If a short is in the cable, splice according to instructions in Section 2.4.
- ☐ Water may have penetrated the interior of the sensor. There is no remedial action.

SYMPTOM: SENSOR READING UNSTABLE

- ☐ Make sure the shield drain wire is connected to the blue clip on the flying leads.
- ☐ Isolate the readout from the ground by placing it on a piece of wood or another insulator.
- ☐ Check for sources of nearby electrical noise such as motors, generators, antennas, or electrical cables. Move the sensor cable away from these sources if possible. Contact the factory for available filtering and shielding equipment.
- ☐ The sensor may have been damaged by over-ranging or shock. Inspect for damage.
- ☐ The body of the sensor may be shorted to the shield. Check the resistance between the shield drain wire and the sensor housing. If the resistance is very low, the sensor conductors may be shorted.
- ☐ Is the readout box position set correctly? If using a data logger to record readings automatically, are the swept frequency excitation settings correct?
- ☐ The sensor shaft may be positioned outside the specified range (either extension or retraction). When the shaft is fully retracted with the alignment pin inside the alignment slot, the readings will likely be unstable because the vibrating wire is under-tensioned.
- ☐ Check the readout with another sensor to ensure it is functioning properly.

SYMPTOM: SENSOR FAILS TO GIVE A READING

- ☐ Check the readout with another sensor to ensure it is functioning properly.
- ☐ The sensor may have been damaged by over-ranging or shock. Inspect for damage.
- ☐ Check the resistance of the cable by connecting an ohmmeter to the sensor leads. Cable resistance is about 48.5 Ω per km (14.7 Ω per 1000'). If the resistance is very high or infinite, the cable is probably broken. If the resistance is very low, the sensor conductors may be shorted. If a break or a short is present, splice according to the instructions in Section 2.4. Refer to the expected resistance for the various wire combinations below.

  Vibrating Wire Sensor Lead Resistance Levels

  Red/Black Coil Resistance: ≅50 Ω

  Green/White 3000 Ω at 25 °C

  Any other wire combination will result in a measurement of infinite resistance.

Note: Tests should be performed with a quality multimeter to accurately show possibilities of shorts. Sensors should be disconnected from other equipment while performing resistance tests, this includes surge modules, terminals, multiplexers and data loggers. Fingers cannot be touching the multimeter leads or sensor wires while testing.

Table 4 shows the expected resistance for the various wire combinations.

Table 5 is provided for the customer to fill in the actual resistance found.

Vibrating Wire Sensor Lead Grid - SAMPLE VALUES					
	Red	**Black**	**White**	**Green**	**Shield**
Red					
Black	**≅50 Ω**				
White	Infinite	Infinite			
Green	Infinite	Infinite	**3000 Ω at 25°C**		
Shield	Infinite	Infinite	Infinite	Infinite	

TABLE 4: *Sample Resistance*

Vibrating Wire Sensor Lead Grid - SENSOR NAME/##					
	Red	**Black**	**White**	**Green**	**Shield**
Red					
Black					
White					
Green					
Shield					

TABLE 5: *Resistance Worksheet*

APPENDIX A. SPECIFICATIONS

A.1 MODEL 4422 SPECIFICATIONS

Range	4 mm, ±2 mm (0.16”, ±0.08”)
Resolution	±0.025% F.S.
Linearity	±0.5% F.S.
Accuracy[1]	±0.1% F.S.
Thermal Zero Shift[2]	< 0.05% F.S./°C
Stability	< 0.2%/yr (under static conditions)
Overrange	115% F.S.
Temperature Range	-20 to +80 °C
Frequency Range	1400 - 3500 Hz
Coil Resistance	50 Ω, ±5 Ω
Cable Type[3]	Two twisted pair (four conductor) 22 AWG Foil shield, PVC jacket, nominal OD=6.3 mm (0.250")
Dimensions (Length x Diameter)	125 x 8 mm (4.908 x 0.31”)
Readout Position	B

TABLE 6: *Model 4422 Vibrating Wire Monument (Micro) Crackmeter Specifications*

Note:

[1] Accuracy established under lab conditions.

[2] Depends on Application.

[3] Polyurethane jacket cable available.

A.2 THERMISTOR

See Appendix B for more information.

Range: -80 to +150 °C

Accuracy: ±0.5 °C

APPENDIX B. THERMISTOR TEMPERATURE DERIVATION

B.1 3KΩ THERMISTOR RESISTANCE

Thermistor Types include YSI 44005, Dale #1C3001–B3, Alpha #13A3001–B3, and Honeywell 192–302LET–A01.

Resistance to Temperature Equation:

$$T = \frac{1}{A + B(LnR) + C(LnR)^3} - 273.15$$

EQUATION 7: *3KΩ Thermistor Resistance*

Where:

T = Temperature in °C

LnR = Natural Log of Thermistor Resistance

$A = 1.4051 \times 10^{-3}$

$B = 2.369 \times 10^{-4}$

$C = 1.019 \times 10^{-7}$

Note: Coefficients calculated over the –50 to +150 °C span.

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

TABLE 7: *3KΩ Thermistor Resistance*

GEOKON®

Vibrating Wire Displacement Transducer Calibration Report

Model: S-A4422-4MM

Serial Number: 1843001

Calibration Instruction: CI-4400

Cable Length: N/A

Calibration Date: March 20, 2020

Temperature: 21.8 °C

Technician: *Kathy Rogers*

GK-401 Reading Position B

Actual Displacement (mm)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Displacement (Linear)	Error Linear (%FS)	Calculated Displacement (Polynomial)	Error Polynomial (%FS)
0.0	2467	2466	2467	0.00	-0.11	0.00	0.03
0.8	3083	3082	3083	0.80	0.01	0.80	-0.02
1.6	3695	3695	3695	1.60	0.02	1.60	-0.09
2.4	4313	4312	4313	2.41	0.19	2.40	0.08
3.2	4920	4921	4921	3.20	0.05	3.20	0.03
4.0	5526	5526	5526	3.99	-0.17	4.00	-0.03

(mm) Linear Gauge Factor (G): 0.001307 **(mm/ digit)** **Regression Zero:** 2470

Polynomial Gauge Factors: **A:** 4.3879E-09 **B:** 0.001272 **C:** ______________

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

(inches) Linear Gauge Factor (G): 0.00005144 **(inches/digit)**

Polynomial Gauge Factors: **A:** 1.7275E-10 **B:** 0.00005006 **C:** ______________

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

Calculated Displacement: **Linear,** $D = G(R_1 - R_0)$

Polynomial, $D = AR_1^2 + BR_1 + C$

Refer to manual for temperature correction information.

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

FIGURE 5: *Typical Calibration Report*