Model 4420 Series

Vibrating Wire Crackmeter

Instruction Manual

GEOKON®

WARRANTY STATEMENT

GEOKON warrants its products to be free of defects in materials and workmanship, under normal use and service for a period of 13 months from date of purchase. If the unit should malfunction, it must be returned to the factory for evaluation, freight prepaid. Upon examination by GEOKON, if the unit is found to be defective, it will be repaired or replaced at no charge. However, the WARRANTY IS VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive corrosion or current, heat, moisture or vibration, improper specification, misapplication, misuse or other operating conditions outside of GEOKON's control. Components that wear or are damaged by misuse are not warranted. This includes fuses and batteries.

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1. INTRODUCTION

GEOKON Model 4420 vibrating wire crackmeters are designed to measure movement across tension cracks in soils, joints in rock and concrete, construction joints in buildings, bridges, pipelines, dams, and more.

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 to a connecting rod at the other. The unit is fully sealed and operates at pressures of up to 250 psi. As the connecting rod is pulled out from the gauge body, the spring is elongated causing an increase in tension, which is sensed by the vibrating wire element. The increase in tension (strain) of the wire is directly proportional to the extension of the shaft. This change in strain allows the Model 4420 to measure the opening of the joint very accurately.

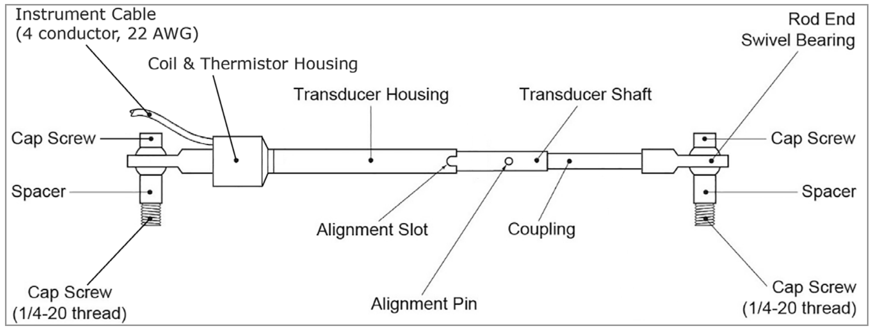

FIGURE 1: *Model 4420 Vibrating Wire Crackmeter*

Models 4420-3, 4420-12.5, and 4420-25 differ slightly from the standard crackmeter in that they provide for adjustment of the setting distance with a threaded extension rod and locking nut.

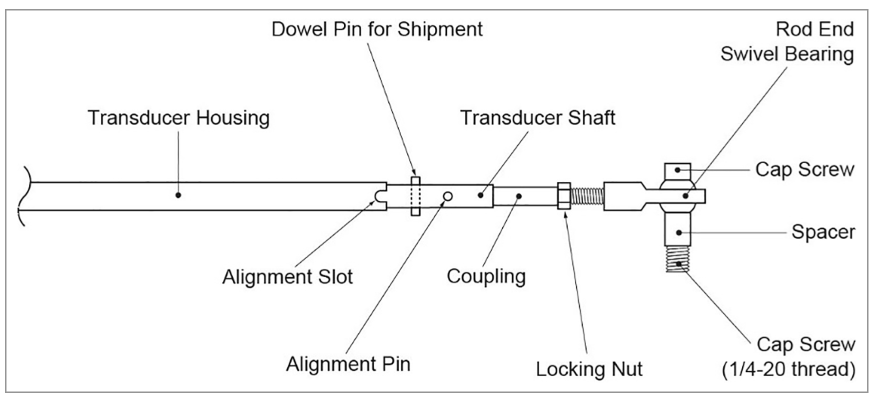

FIGURE 2: *Model 4420-3, -12.5, -25 Detailed View*

CAUTION! Never extend the crackmeter beyond its working range or rotate the shaft more than 180 degrees. (The transducer shaft may be rotated 90 degrees in either direction to align the mounting points.)

2. INSTALLATION

2.1 PRELIMINARY TESTS

Check the gauge for proper operation when you receive it. Check the thermistor as well. The crackmeter normally arrives with its shaft secured at approximately 50% of its range.

For crackmeters with a range of 100 mm (4") or smaller, the shaft is secured using a dowel pin held in place by a piece of tape (see Figure 1).

For crackmeters with a range greater than 100 mm, a slotted sleeve made of PVC secures the shaft.

These devices hold the crackmeter in tension to protect it during shipping. With the shipping spacers still in place, connect the gauge to a readout box and take a reading. (See Section 4.1 for readout instructions.) The reading should be stable and in the range of 4000 to 5000 digits. Please note that crackmeters with a 3 mm (.125") range are shipped with the push rod fully retracted and have no shipping spacer to remove. These gauges should read between 2000 to 3000 digits.

Check electrical continuity using an ohmmeter. Be sure to consider the following:

- Resistance between the gauge leads should be approximately 180 ohms, ±10 ohms (128 ohms for the Model 4420HT).
- Remember to add the cable resistance, which is approximately 14.7Ω per 1000 ft. (48.5Ω per km) of 22 AWG stranded copper leads at 20 °C.
- Multiply this factor by two to account for both directions.
- Resistance between the green and white conductors will vary based on temperature.
  - For standard crackmeters, refer to Table 7 in Appendix B.
  - For the 4420HT crackmeter, refer to Table 8 in Appendix C.
- Resistance between any conductor and the shield should exceed two megohms.

Carefully remove the PVC slotted sleeve or dowel pin before proceeding further. Hold the transducer shaft to prevent it from snapping into the transducer housing.

2.2 CRACKMETER INSTALLATION

For additional instructions Models 4420HT and 4420-3, see Appendix C and Appendix E respectively. For additional instructions regarding 3D Arrays, see Appendix D.

2.2.1 ANCHORS

Three types of anchors are available:

- Weldable Mounting Fixture
- Expansion Anchor
- Groutable Anchor

The weldable fixture is designed to aid in mounting the crackmeter on steel members. The machine bolt expansion anchors and groutable anchors are used to install the crackmeter on concrete or rock. The anchors are installed at the appropriate spacing distance, depending on the anticipated direction of movement (extension or compression). Refer to the table below.

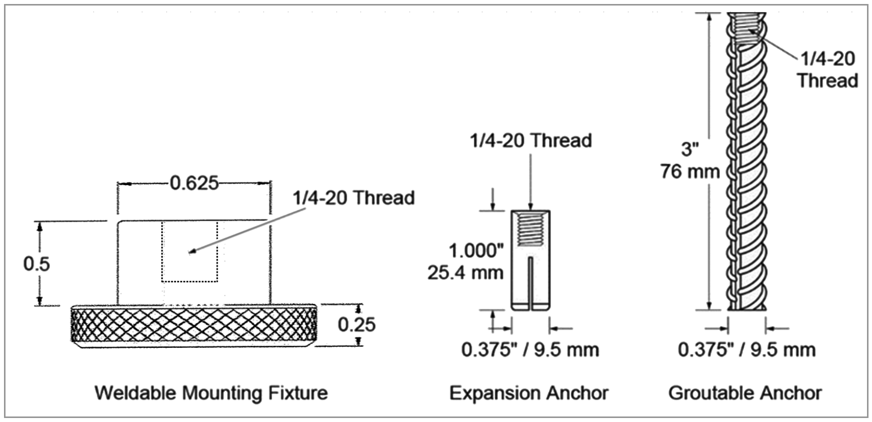

FIGURE 3: *Anchor Types with Dimensions*

Section 2.2.2 through Section 2.2.4 contain detailed instructions on each type of anchor. Section 2.3 contains special instructions on the following models:

- 4420-1-3 mm (.125")
- 4420-1-12.5 mm (.5")
- 4420-1-25 mm (1")

Model & Range	Midrange	To Monitor Extension	To Monitor Compression
4420-3 mm (.125")	292.6 mm (11.52")	291.1 mm (11.46")	294.1 mm (11.58")
4420-12.5 mm (.5")	317 mm (12.5")	310 mm (12.2")	325 mm (12.8")
4420-25 mm (1")	343 mm (13.5")	330 mm (13")	356 mm (14")
4420-50 mm (2")	396 mm (15.6")	371 mm (14.6")	422 mm (16.6")
4420-100 mm (4")	554 mm (21.8")	503 mm (19.8")	605 mm (23.8")
4420-150 mm (6")	645 mm (25.4")	569 mm (22.4")	721 mm (28.4")
4420-200 mm (8")	869 mm (34.2")	767 mm (30.2")	970 mm (38.2")
4420-300 mm (12")	1186 mm (46.7")	1034 mm (40.7")	1339 mm (52.7")
Note for Model 4420HT: Due to the U-joint configuration of 4420HT, the overall gauge assembly length is increased by 35 mm (1.375"). This length should be added to the anchor spacing distance shown above.			

TABLE 1: *Crackmeter Anchor Spacing Distances*

When setting the gauge position using a portable readout, use the reading ranges in the table below to determine the proper position.

Approximate Midrange Reading	Approximate Reading to Monitor Extensions	Approximate Reading to Monitor Compressions
4500-5000	2500-3000	6500-7000

TABLE 2: *Crackmeter Reading Ranges*

Be sure to consider the following:

- Note that the calibration sheet (see Figure 12) supplied with the crackmeter shows factory 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 its range, either in anticipation of closure or opening of the crack.
- Extend the crackmeter until the desired reading is obtained.

- Hold the crackmeter in this position while the distance between the cap screws is measured (set inside the swivel bearings, see Figure 1).
- This measurement can serve as a spacing guide for drilling or welding the anchor points.
- Use the alignment pin on the transducer shaft and slot on the body as a guide for alignment.
- The transducucer shaft may be rotated 90 degrees in either direction to align the mounting points. **CAUTION! Never rotate the shaft more than 180 degrees.**

2.2.2 INSTALLATION USING WELDABLE FIXTURES

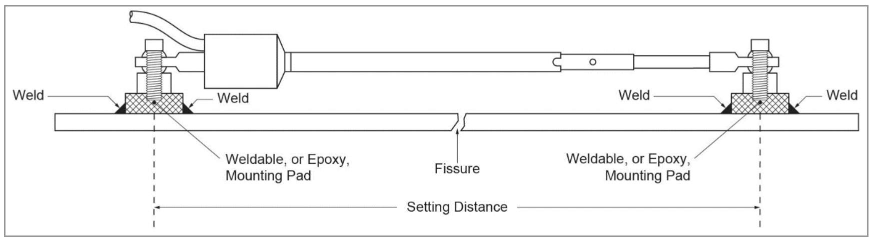

FIGURE 4: *Installation using Weldable Fixtures*

INSTALLATION INSTRUCTIONS:

1. Determine the proper setting distance using the spacings listed in Table 1.
2. Grind, sand, or otherwise prepare the surface of the steel around the area of each weldable fixture.
3. Position the welding fixtures on prepared surfaces.
4. Verify the placement again, then tack weld to the member.
5. Remove the PVC slotted sleeve or dowel pin securing the transducer shaft.
6. Thread the cap screw through the swivel bearing and through the half-inch spacer on each end.
7. Tighten the cap screws into the welding fixtures as depicted in Figure 4.
8. Check and record the reading with a portable readout. Use Table 2 or the readings on the calibration sheet to check the position.

2.2.3 INSTALLATION USING GROUTABLE ANCHORS

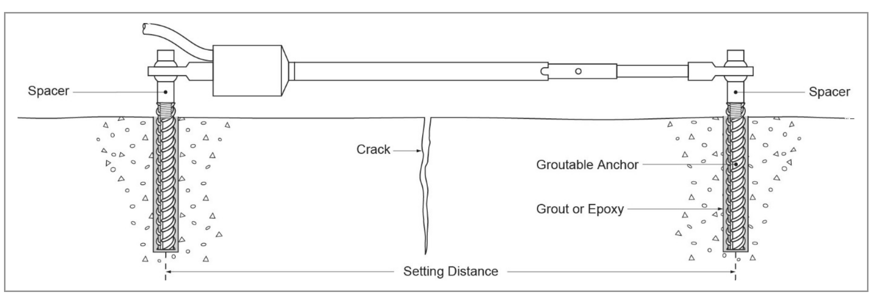

FIGURE 5: *Installation using Groutable Anchors*

INSTALLATION INSTRUCTIONS:

1. Determine the proper setting distance using the spacings listed in Table 1.

2. Using a hammer drill (or other suitable equipment), drill two half-inch diameter holes approximately three inches deep at the proper locations. Shorter holes may be drilled if the anchors are cut down accordingly.
3. Push the cap screws through the swivel bearings and spacers on each end of the crackmeter and then loosely thread them into the groutable anchors.
4. For midrange position installations, secure the transducer shaft in place by leaving the PVC slotted sleeve or dowel pin installed.
5. Fill the holes three quarters full with grout or epoxy. For holes drilled overhead use a quick setting grout or epoxy.
6. Push and twist the anchors in until the tops are flush with the surface. Wipe any excess epoxy clear of the tops of the anchors.
7. After the grout or epoxy has set, install and tighten the set screws.
8. Remove the PVC slotted sleeve or dowel pin if it was not removed earlier.
9. Check and record the reading with a portable readout. Use Table 2 to check and adjust the position as needed.

2.2.4 INSTALLATION USING EXPANSION ANCHORS

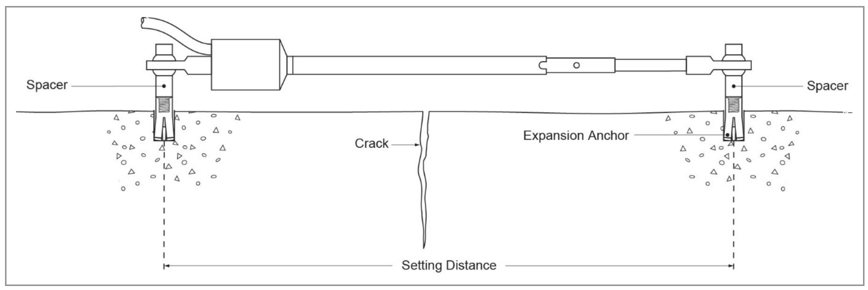

FIGURE 6: *Installation using Expansion Anchors*

INSTALLATION INSTRUCTIONS:

1. Determine the proper setting distance using the spacings listed in Table 1.
2. Using a masonry drill (or other suitable equipment), drill two 10 mm (3/8") diameter holes, 32 mm (1.25") deep at the proper locations.
3. Insert the expansion anchors into the holes, with the slotted end down.
4. Insert the setting tool into the anchor, small end first. Expand the anchor by hitting the large end of the setting tool with several sharp hammer blows.
5. Remove the PVC slotted sleeve or dowel pin securing the transducer shaft.
6. Push the cap screws through the swivel bearings and spacers on each end of the crackmeter and then tighten the cap screws into the anchors.
7. Check and record the reading with a portable readout. Use Table 2 to check and adjust the position as needed.

2.3 SPECIAL INSTALLATION NOTE

Regarding Models 4420-1-3 mm (.125"), 4420-1-12.5 mm (.5"), and 4420-1-25 mm (1"), please keep the following in mind:

- If the reading is not in the proper range after installation, make adjustments using the threaded extension at the end of the transducer shaft.
- To make accurate adjustments, attach the transducer to the anchor at the cable end, and temporarily remove it from the opposite anchor.

TO MAKE AN ADJUSTMENT, DO THE FOLLOWING:

1. Loosen the locking nut and then rotate the threaded rod into or out of the end of the transducer shaft.
   Note: Grip the transducer shaft while rotating the threaded rod.
   Never rotate the transducer shaft beyond 180 degrees, or gauge failure may result.
2. After making an adjustment, align the hole in the swivel bearing over the anchor and check the reading.
3. Make adjustments until the desired reading displays on the readout.
4. Push the cap screw through the swivel bearing and spacer.
5. Tighten into the anchor.
6. Re-tighten the locking nut.

3. INSTRUMENT PROTECTION

3.1 CABLE SPLICING AND TERMINATION

Terminal boxes with sealed cable entries are available from GEOKON for all types of applications. These allow many instruments 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. Contact GEOKON for specific application information.

Because the vibrating wire output signal is a frequency rather than a current or voltage, variations in cable resistance have little effect on instrument readings; therefore, splicing of cables has no ill effects, and in some cases may in fact be beneficial. The cable used for making splices should be a high quality twisted pair type, with 100% shielding and an integral shield drain wire. **When splicing, it is very important that the shield drain wires be spliced together**. Always maintain polarity 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.

Terminate a cable by stripping and tinning the individual conductors and then connecting them to the patch cord of a readout box. Alternatively, use a connector to plug directly into the readout box or to a receptacle on a special patch cord.

3.2 PROTECTION FROM MECHANICAL DAMAGE

It is important that you protect the crackmeter from damage. GEOKON makes steel cover plates, Model 4420-7, for this purpose. GEOKON makes them using sheet steel formed into a channel shape. The standard cover plate is long enough to cover the two-inch range crackmeter; longer range crackmeters use multiple cover plates tack-welded together.

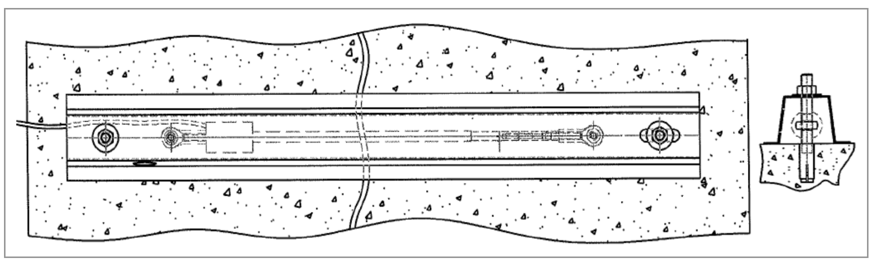

FIGURE 7: *Typical Cover Plate Installation*

The mounting nut and washer should be tightened only loosely to enable the cover to slide on the 3/8 threaded rods. An extra nut is provided as a locknut. Critical dimensions of the extended range covers are shown in the table below.

Range	Total Length	Hole Spacing	Slot Lengths
100 mm (4")	36"	32.5"	2"
150 mm (6")	36"	31.5"	3"
200 mm (8")	48"	42.5"	4"
300 mm (12")	60"	52.5"	6"

TABLE 3: *Dimensions of Extended Range Covers*

3.3 CABLE AND CONNECTOR PROTECTION

The cable should be protected from accidental damage caused by moving equipment or fly rock. This is best accomplished by putting the cable inside flexible conduit and positioning the conduit in as safe a place as possible. (Flexible conduit is available from GEOKON.) The conduit can be connected via conduit bulkhead connectors to the cover plates. (The GEOKON cover plate has a stamped knockout which, when removed, provides a hole for connecting the conduit connector.)

3.4 PROTECTION FROM CORROSION

It is imperative that installation weld points, if any, be protected from corrosion. Stainless steel instruments will not corrode, but the substrate can corrode, especially at weld points, unless they are covered by a waterproofing layer. GEOKON recommends you follow this procedure:

1. Apply several drops of cyanoacrylate adhesive to the edge of all spot welded mounting tabs. The glue will wick into the gap between the mounting tabs and the substrate and provide the first line of defense.
2. Mask off the areas where spot welds are needed.
3. Spray a coat of self-etching primer (available at any auto parts store) over mounting tab areas and all exposed bare metal areas. The idea is to protect substrate weld points. It is important to completely cover mounting tab edges, paying particular attention to the point where the tab is under the instrument. Be sure to spray beneath the coil housing, if applicable; do not worry if the primer also coats the instrument.
4. Apply a coat of paint over the primed areas.

3.5 PROTECTION FROM ELECTRICAL NOISE

Be sure to 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.

3.6 PROTECTION FROM SUNLIGHT AND TEMPERATURE CHANGES

If attached to a steel structure, the thermal coefficient of expansion of the steel vibrating wire inside the instrument is the same as that for the structure. This means that no temperature correction for the measured strain is required when calculating load-induced strains. However, this is only true if the wire and the underlying steel structure are at the same temperature. If sunlight is allowed to impinge directly onto the gauge, it could elevate the temperature of the wire above the surrounding steel and cause large changes in apparent strain. Therefore, always shield strain gauges from direct sunlight. Protection from thermal effects is best provided by covering the gauges with a layer of insulating material such as Polystyrene foam or fiberglass.

3.7 LIGHTNING PROTECTION

Unlike numerous other types of instrumentation available from GEOKON, vibrating wire strain instruments do not have any integral lightning protection components, such as transorbs or plasma surge arrestors.

SUGGESTED LIGHTNING PROTECTION OPTIONS:

- Lighting arrestor boards and enclosures are available from GEOKON. These units install where the instrument cable exits the structure being monitored.

The enclosure has a removable top to allow the customer to service the components or replace the board in the event that the unit is damaged by a lightning strike. A connection is made between the enclosure and earth ground to facilitate the passing of transients away from the instruments. See the figure below.

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

Consult the factory for additional information on available lightning protection.

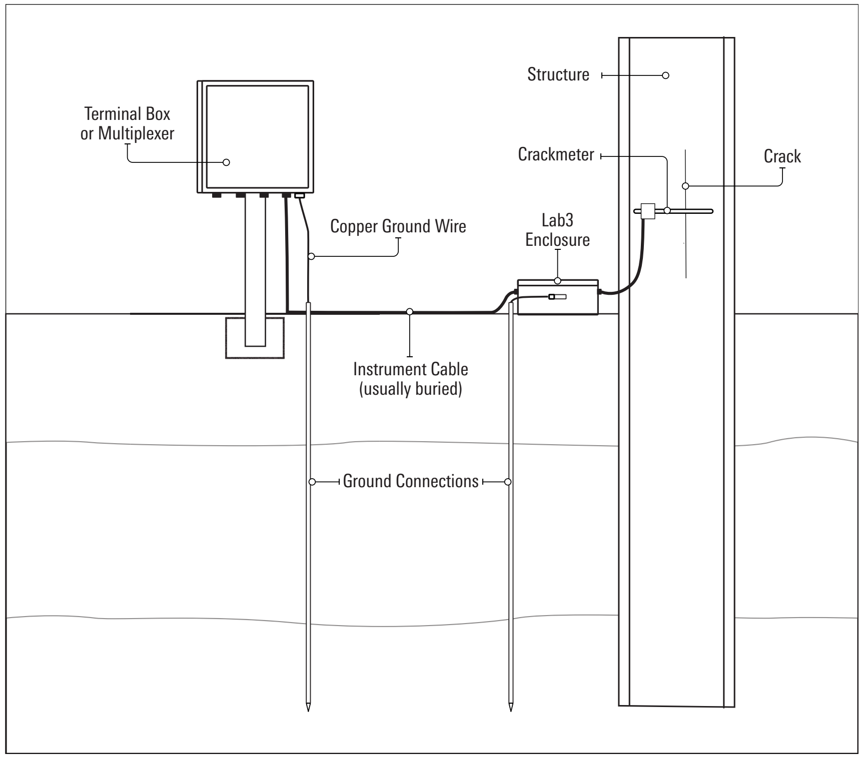

FIGURE 8: *Lightning Protection Scheme*

4. TAKING READINGS

4.1 GK-404 VIBRATING WIRE READOUT

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

FIGURE 9: *GK-404 Readout*

4.1.1 OPERATING THE GK-404

FIGURE 10: *Lemo Connector to GK-404*

1. Attach the flying leads by aligning the red circle on the silver Lemo connector with the red line on the top of the GK-404 (see Figure 10). Insert the Lemo connector into the GK-404 until it locks into place.
2. Connect each of the clips on the leads to the matching colors of the sensor conductors, with blue representing the shield (bare).
3. To turn on the GK-404, press the **On/Off** button on the front panel of the unit. The initial startup screen will display.
4. After a delay, the GK-404 will start taking readings and display them based on the settings of the **Pos** and **Mode** buttons.

The unit display (from left to right) is as follows:

- The current position: set by the **Pos** button, displayed as A through F.
- The current reading: set by the **Mode** button, displayed as a numeric value followed by the unit of measure.
- Temperature reading of the attached instrument in degrees Celsius.

Use the **Pos** and **Mode** buttons to select the correct position and display units for the model of equipment purchased.

The GK-404 will continue to take measurements and display readings until the unit is turned off, either manually or by the Auto-Off timer (if enabled).

For more information, consult the GK-404 manual.

4.2 GK-405 VIBRATING WIRE READOUT

The GK-405 Readout is made up of two components:

- The Readout Unit, consisting of a Windows Mobile handheld PC running the GK-405 Vibrating Wire Readout application.
- The GK-405 Remote Module, which is housed in a weather-proof enclosure.

The remote module can be wire-connected to the sensor by means of:

- Flying leads with alligator clips, if the sensor cable terminates in bare wires.
- A 10 pin connector.

FIGURE 11: GK-405 Readout

The two units communicate wirelessly using Bluetooth®, a reliable digital communications protocol. Using Bluetooth, the unit can operate from the cradle of the remote module, or, if more convenient, can be removed and operated up to 20 meters away from the remote module.

The GK-405 displays the thermistor temperature in degrees Celsius.

For further details, consult the GK-405 Instruction Manual.

4.2.1 CONNECTING SENSORS WITH 10-PIN BULKHEAD CONNECTORS ATTACHED

Align the grooves on the sensor connector (male), with the appropriate connector on the readout (female connector, labeled senor or load cell). Push the connector into place, and then twist the outer ring of the male connector until it locks into place.

4.2.2 CONNECTING SENSORS WITH BARE LEADS

Attach the flying leads to the bare leads of a GEOKON vibrating wire sensor by connecting each of the clips on the leads to the matching colors of the sensor conductors, with blue representing the shield (bare).

4.2.3 OPERATING THE GK-405

Press the power button on the Readout Unit. After start-up completes, a blue light will begin flashing, signifying that the two components are ready to connect wirelessly. Launch the GK-405 VWRA program by doing the following:

1. Tap Start on the hand-held PC's main window.
2. Select Programs.
3. Tap the GK-405 VWRA icon.

After a few seconds, the blue light should stop flashing and remain lit. The Live Readings window will display on the hand-held PC.

Set the Display mode to the correct letter required by your equipment. For more information, consult the GK-405 Instruction Manual.

4.3 MEASURING TEMPERATURES

All GEOKON vibrating wire instruments 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 instrument cable are normally connected to the internal thermistor.

The GK-404 and GK-405 readouts will read the thermistor and display the temperature in degrees Celsius.

Note: You must use an ohmmeter to read the 4420HT strain gauge.

TO READ TEMPERATURES USING AN OHMMETER:

1. Connect an ohmmeter to the green and white thermistor leads coming from the instrument. 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 48.5Ω per km (14.7Ω per 1000') at 20 °C. Multiply these factors by two to account for both directions.
2. Look up the temperature for the measured resistance in Appendix B. For the 4420HT refer to Appendix C.

5. DATA REDUCTION

5.1 DISPLACEMENT CALCULATION

The basic units utilized by GEOKON for measurement and reduction of data from vibrating wire crackmeters are digits. Calculation of digits is based on the following equation:

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

EQUATION 1: *Digits Calculation*

To convert digits to displacement the following equation applies:

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

EQUATION 2: *Displacement Calculation*

Where:

R_1 is the current reading.
R_0 is the initial reading, usually obtained at installation.
G is the gauge factor, usually millimeters or inches per digit (see Figure 12).
F is an optional engineering units conversion factor (see the table below).

From To	Inches	Feet	Millimeters	Centimeters	Meters
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 4: *Engineering Units Conversion Multipliers*

For example, the initial reading R_0, at installation of a crackmeter is 2500 digits. The current reading, R_1, is 6000. The gauge factor is 0.006223 mm/digit. The displacement change is:

$D_{uncorrected} = (6000 - 2500) \times 0.006223 \times +21.78$

EQUATION 3: *Displacement Change*

Note that increasing readings (digits) indicate increasing extension.

To use the polynomial gauge factors given on the calibration sheet, use the value of R_0 and Gauge Factors A and B with D set to zero to calculate the new value of C. Then substitute the new value of R_1 and use A, B, and the new value of C to calculate the displacement D.

GEOKON

Vibrating Wire Displacement Transducer Calibration Report

Model: 4420-1-25MM

Serial Number: 1838201

Calibration Instruction: CI-4400

Cable Length: 3 meters

Calibration Date: October 04, 2018

Temperature: 23.4 °C

Technician:

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	2350	2350	2350	-0.04	-0.17	0.00	-0.01
5.0	3202	3202	3202	5.01	0.05	5.00	0.00
10.0	4050	4049	4050	10.04	0.15	10.00	0.01
15.0	4892	4891	4892	15.03	0.13	15.00	-0.01
20.0	5731	5730	5731	20.01	0.03	20.00	0.00
25.0	6566	6565	6566	24.96	-0.16	25.00	0.01

(mm) Linear Gauge Factor (G): 0.005931 **(mm/ digit)** **Regression Zero:** 2357

Polynomial Gauge Factors: **A:** 1.7735E-08 **B:** 0.005773 **C:**

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

(inches) Linear Gauge Factor (G): 0.0002335 **(inches/digit)**

Polynomial Gauge Factors: **A:** 6.9823E-10 **B:** 0.0002273 **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 12: *Typical Crackmeter Calibration Sheet*

5.2 TEMPERATURE CORRECTION

GEOKON's vibrating wire displacement transducers have a small coefficient of thermal expansion. Correction may not be necessary in most cases. However, to achieve maximum accuracy, there are corrections that you can apply.

Use the following equation to provide thermal correction of the instrument:

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

EQUATION 4: *Thermally-Corrected Displacement Calculation*

Where:
R_1 is the current reading
R_0 is the initial reading
G is the linear gauge factor
T_1 is the current temperature
T_0 is the initial temperature
K is the thermal coefficient (see Equation 5)

Tests have determined that the thermal coefficient, K, changes with the position of the transducer shaft. 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 5: *Thermal Coefficient Calculation*

Where:
R_1 is the current reading
M is the multiplier, from Table 5
B is the constant, from Table 5
G is the linear gauge factor from the supplied calibration sheet.

Model:	Multiplier (M):	Constant (B):
4420-3 mm (0.125")	0.000520	3.567
4420-12 mm (0.5")	0.000375	1.08
4420-25 mm (1")	0.000369	0.572
4420-50 mm (2")	0.000376	0.328
4420-100 mm (4")	0.000398	0.0864
4420-150 mm (6")	0.000384	-0.3482
4420-200 mm (8")	0.000396	-0.4428
4420-300 mm (12")	0.000424	-0.6778

TABLE 5: *Thermal Coefficient Calculation Constants*

Consider the following example using a Model 4420-200 mm crackmeter:

R_0 = 4773 digits
R_1 = 4589 digits
T_0 = 20.3 °C
T_1 = 32.9 °C
G = 0.04730 mm/digit
K = (((4589 x 0.000396) – 0.4428) x 0.04730) = 0.065011
$D_{corrected}$ = $((R_1 - R_0) \times G) + ((T_1 - T_0) \times K)$
$D_{corrected}$ = ((4589 – 4773) x 0.04730) + ((32.9 – 20.3) x 0.065011)
$D_{corrected}$ = (–184 x 0.04730) + 0.819
$D_{corrected}$ = –8.7032 + 0.819
$D_{corrected}$ = –7.8842 mm

The temperature coefficient of the mass or member to which the crackmeter is attached should also be taken into account. Use the temperature coefficient of the mass or member, combined with the changes in temperature from initial to current readings, to determine thermal effects of the mass or member.

5.3 ENVIRONMENTAL FACTORS

Because the purpose of using a crackmeter 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.

6. TROUBLESHOOTING

Maintenance and troubleshooting is confined to periodic checks of cable connections and maintenance of terminals. Once installed, these instruments are usually inaccessible and remedial action is limited. Should difficulties arise, consult the following list of problems and possible solutions. Return any faulty gauges to the factory. **Instruments should not be opened in the field.** For additional troubleshooting and support, contact GEOKON.

SYMPTOM: THERMISTOR RESISTANCE IS TOO HIGH

- ☐ Check for an open circuit. Check all connections, terminals, and plugs. If a cut is located in the cable, splice according to instructions in Section 3.1.

SYMPTOM: THERMISTOR RESISTANCE IS TOO LOW

- ☐ Check for a short circuit. Check all connections, terminals, and plugs. If a short is located in the cable, splice according to instructions in Section 3.1.
- ☐ Water may have penetrated the interior of the instrument. There is no remedial action.

SYMPTOM: INSTRUMENT 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 instrument shaft positioned outside the specified range (either extension or retraction) of the instrument? 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.
- ☐ Is there a source of electrical noise nearby? Likely candidates are generators, motors, arc welding equipment, high voltage lines, etc. If possible, move the instrument cable away from power lines and electrical equipment or install electronic filtering.
- ☐ Make sure the shield drain wire is connected to ground. Connect the shield drain wire to the readout using the blue clip.
- ☐ Does the readout or datalogger work with another instrument? If not, it may have a low battery or possibly be malfunctioning.

SYMPTOM: INSTRUMENT FAILS TO READ

- ☐ Does the readout or datalogger work with another instrument? If not, it may have a low battery or possibly be malfunctioning.
- ☐ Is the cable cut or crushed? Check the resistance of the cable by connecting an ohmmeter to the sensor leads; resistance is approximately 48.5 per km (14.7 per 1000') of 22 AWG wire.

  If the resistance is very high or infinite, the cable is probably broken. If the resistance is very low, the conductors may be shorted. If a break or a short is present, splice according to the instructions in Section 3.1.

  Refer to the expected resistance for the various wire combinations below.

  Vibrating Wire Sensor Lead Resistance Levels
  Red/Black ≅180Ω (≅128Ω for Model 4420HT)
  Green/White 3000 at 25 °C

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

APPENDIX A. SPECIFICATIONS

MODEL 4420 CRACKMETER

The table below lists the specifications for all models except for the Model 4420-3 Low Profile Crackmeter. For information on that model, refer to Appendix E.

Range:	3 mm/0.125"	12 mm/0.50"	25 mm/1"	50 mm/2"	100 mm/4"	150 mm/6"	200 mm/8"	300 mm/12"
Resolution:[1]	0.025% FSR							
Linearity:	0.25% FSR							
Thermal Zero Shift:[2]	< 0.05% FSR/°C							
Stability:	< 0.2% / yr (under static conditions)							
Overrange:	115% FSR							
Temperature Range:	-20 to +80 °C -5 to +175 °F							
Frequency Range:	1400-3500 Hz							
Coil Resistance:	180Ω, +10Ω							
Cable Type:[3]	Two twisted pair (four conductor) 22 AWG Foil shield, PVC jacket, nominal OD=6.3 mm (0.250")							
Cable Wiring Code:	Red and Black are the VW Sensor, White and Green are the Thermistor.							
Length: (midrange, end to end)	312 mm/ 12.3"	337 mm/ 13.3"	362 mm/ 14.3"	415 mm/ 16.4"	573 mm/ 22.6"	664 mm/ 26.2"	889 mm/ 35"	1205 mm/ 47.5"
Coil Assembly Dim.: (length x OD)	31.75 mm/25.4 mm 1.25"/1"							

TABLE 6: *Model 4420 Crackmeter Specifications*

Notes:

[1] Minimum, greater resolution possible depending on readout.

[2] Depends on application.

[3] Polyurethane jacket cable available.

APPENDIX B. THERMISTOR TEMPERATURE DERIVATION

3KΩ THERMISTOR RESISTANCE

Thermistor Types:

- YSI 44005, Dale #1C3001–B3, Alpha #13A3001–B3
- Honeywell 192–302LET–A01

Resistance to Temperature Equation:

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

EQUATION 6: *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*

APPENDIX C. MODEL 4420HT – HIGH TEMPERATURE VERSION

Model 4420HT is a high-temperature crackmeter, rated to 200 °C. This model is supplied with 316 stainless steel U-joints on the ends, as opposed to the rod end bearings installed on standard crackmeters. Due to the U-joint configuration, the overall instrument assembly length is 35 mm (1.375") longer, which you must add when determining anchor spacing distance using in Table 1.

The epoxied diameter is slightly larger with the HT version due to added waterproofing and strain relief for the Teflon cable. This results in a space of about 14.5 mm (0.569") between the U-joint and the outer diameter of the epoxy. The standard spacer supplied with anchors as shown in Figure 5 and Figure 6 is about 12.7 mm (.500"); therefore, interference between the epoxied area and the mounted surface may occur. To ensure this doesn't happen, either rotate the assembly 180 degrees on its axis, or use the larger supplied spacers.

4420HT crackmeters are supplied with a high temperature thermistor that has a range of -55 to +300 °C, and an accuracy of ±0.5 °C. To convert ohms to temperature, use Equation 7 or Table 8 below.

Thermistor Type: US Sensor 103JL1A

Resistance to Temperature Equation:

$$T = \frac{1}{A+B(LnR)+C(LnR)^3+D(LnR)^5} - 273.15$$

EQUATION 7: *Model 4420HT 10KΩ Thermistor Resistance*

Where:
T = Temperature in °C
LnR = Natural Log of Thermistor Resistance
A = 1.127670×10^{-3}
B = 2.344442×10^{-4}
C = 8.476921×10^{-8}
D = 1.175122×10^{-11}

Note: Coefficients optimized for a curve **J** Thermistor over the temperature range of 0 °C to +250 °C.

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
32,650	0	7,402	32	2,157	64	763.5	96	316.6	128	148.4	160	76.5	192	42.8	224
31,029	1	7,098	33	2,083	65	741.2	97	308.7	129	145.1	161	75.0	193	42.1	225
29,498	2	6,808	34	2,011	66	719.6	98	301.0	130	142.0	162	73.6	194	41.4	226
28,052	3	6,531	35	1,942	67	698.7	99	293.5	131	138.9	163	72.2	195	40.7	227
26,685	4	6,267	36	1,876	68	678.6	100	286.3	132	135.9	164	70.8	196	40.0	228
25,392	5	6,015	37	1,813	69	659.1	101	279.2	133	133.0	165	69.5	197	39.3	229
24,170	6	5,775	38	1,752	70	640.3	102	272.4	134	130.1	166	68.2	198	38.7	230
23,013	7	5,545	39	1,693	71	622.2	103	265.8	135	127.3	167	66.9	199	38.0	231
21,918	8	5,326	40	1,637	72	604.6	104	259.3	136	124.6	168	65.7	200	37.4	232
20,882	9	5,117	41	1,582	73	587.6	105	253.1	137	122.0	169	64.4	201	36.8	233
19,901	10	4,917	42	1,530	74	571.2	106	247.0	138	119.4	170	63.3	202	36.2	234
18,971	11	4,725	43	1,480	75	555.3	107	241.1	139	116.9	171	62.1	203	35.6	235
18,090	12	4,543	44	1,432	76	539.9	108	235.3	140	114.5	172	61.0	204	35.1	236
17,255	13	4,368	45	1,385	77	525.0	109	229.7	141	112.1	173	59.9	205	34.5	237
16,463	14	4,201	46	1,340	78	510.6	110	224.3	142	109.8	174	58.8	206	33.9	238
15,712	15	4,041	47	1,297	79	496.7	111	219.0	143	107.5	175	57.7	207	33.4	239
14,999	16	3,888	48	1,255	80	483.2	112	213.9	144	105.3	176	56.7	208	32.9	240
14,323	17	3,742	49	1,215	81	470.1	113	208.9	145	103.2	177	55.7	209	32.3	241
13,681	18	3,602	50	1,177	82	457.5	114	204.1	146	101.1	178	54.7	210	31.8	242
13,072	19	3,468	51	1,140	83	445.3	115	199.4	147	99.0	179	53.7	211	31.3	243
12,493	20	3,340	52	1,104	84	433.4	116	194.8	148	97.0	180	52.7	212	30.8	244
11,942	21	3,217	53	1,070	85	421.9	117	190.3	149	95.1	181	51.8	213	30.4	245
11,419	22	3,099	54	1,037	86	410.8	118	186.1	150	93.2	182	50.9	214	29.9	246
10,922	23	2,986	55	1,005	87	400.0	119	181.9	151	91.3	183	50.0	215	29.4	247
10,450	24	2,878	56	973.8	88	389.6	120	177.7	152	89.5	184	49.1	216	29.0	248
10,000	**25**	2,774	57	944.1	89	379.4	121	173.7	153	87.7	185	48.3	217	28.5	249
9,572	26	2,675	58	915.5	90	369.6	122	169.8	154	86.0	186	47.4	218	28.1	250
9,165	27	2,579	59	887.8	91	360.1	123	166.0	155	84.3	187	46.6	219		
8,777	28	2,488	60	861.2	92	350.9	124	162.3	156	82.7	188	45.8	220		
8,408	29	2,400	61	835.4	93	341.9	125	158.6	157	81.1	189	45.0	221		
8,057	30	2,316	62	810.6	94	333.2	126	155.1	158	79.5	190	44.3	222		
7,722	31	2,235	63	786.6	95	324.8	127	151.7	159	78.0	191	43.5	223		

TABLE 8: *Model 4420HT 10KΩ Thermistor Resistance*

APPENDIX D. MODEL 4420-6 2D/3D CRACKMETER

Note: For Model 4420-6-X/Y (2D version), omit the Z axis from the instructions that follow.

D.1 ARRAY OF 3 CRACKMETERS

Monitoring crack movements in three dimensions requires an array of three 4420 crackmeters, one each for monitoring the X, Y, and Z dimensions.

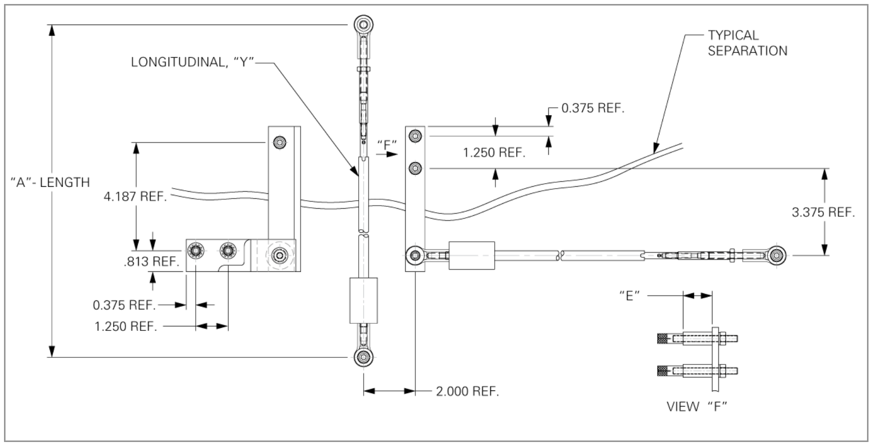

FIGURE 13: *Typical 3D Array - Top View*

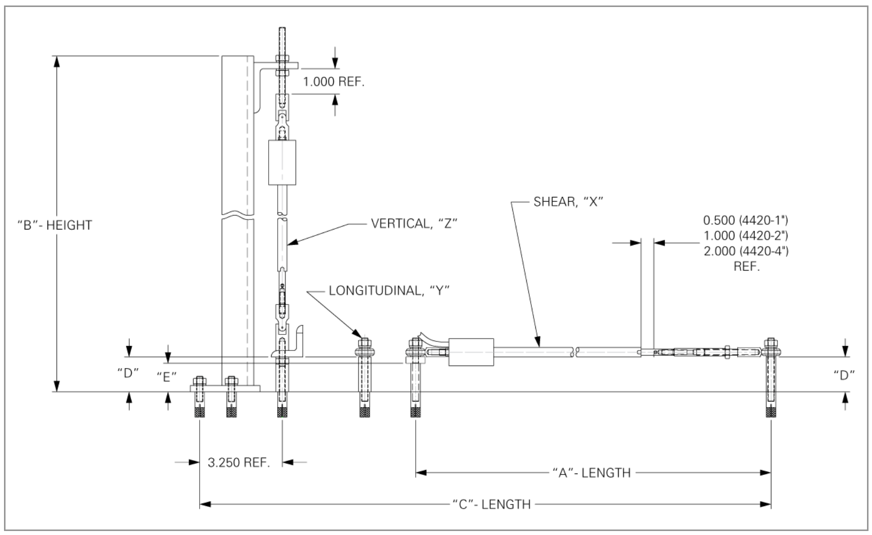

FIGURE 14: *Typical 3D Array - Front View*

Range	'A' Length @ Midrange	'B' Height	'C' Length	'D' Dimension	'E' Dimension
25 mm (1")	342.90 mm (13.50")	384.56 mm (15.14")	558.80 mm (22")	34.93 mm (1.375")	28.58 mm (1.125")
50 mm (2")	396 mm (15.625")	489.28 mm (19.263")	612.78 mm (24.125")	60.33 mm (2.375")	53.98 mm (2.125")
100 mm (4")	554.81 mm (21.843")	701.88 mm (27.633")	770.71 mm (30.343")	111.13 mm (4.375")	104.78 mm (4.125")

TABLE 9: *3D Array, Typical Version*

The ends of the crack meters are fixed on each side of a fissure by means of a bracket or by direct mounting using expansion anchors.

D.2 INSTALLING THE 3D ARRAY

ANCHOR SPACING

For spacing distances, refer to Table 1 in Section 2.2.1. When setting the gauge position using a portable readout, refer to Table 1 in Section 2.2.1 to determine the proper position.

X-AXIS

The X-axis, as shown above, uses a 1/4" x 3/4" stainless steel bar to transfer parallel motion along the axis of the crack. This sensor requires two holes about 32 mm (1.25") apart, both 10 mm (3/8") in diameter and 32 mm deep. The holes must be perpendicular to the crack, and about an inch or two away. Once the anchors are installed with the spacers on top, attach the 5-5/8" long stainless steel bar using the provided threaded rods, lock washers, and nuts.

Note: The spacers used here are 1/8" shorter to accept the width of the bar. The spacing, chosen from Table 1 in Section 2.2.1, is then measured perpendicular from the 1/4-20 tapped hole in the stainless steel bar. Install another expansion anchor and spacer at this location, then attach the crackmeter with rod end bearings using the threaded rod, lock washer, and nuts provided.

Perform the following installation steps:

1. Using a masonry drill (or other suitable equipment), drill two 3/8 inch (10 mm) diameter holes, 1.25" (32 mm) deep, 1.25" apart. The holes should be positioned perpendicular to, and one-two inches in from, the crack.
2. Insert an expansion anchor into each of the holes, slotted end down.
3. Insert the provided setting tool, small end first, into the anchors. Expand each anchor by hitting the large end of the setting tool with several sharp hammer blows.
4. Remove the PVC slotted sleeve or dowel pin securing the transducer shaft.
5. Place the spacers on top of the anchors and attach the 5.625" long stainless steel bar to the anchors using the provided threaded rods, lock washers, and nuts.

   Note: The spacers used here are 1/8" (3.2 mm) shorter than the others to accommodate the width of the bar.
6. Drill another 3/8" (10 mm) diameter, 1.25" (32 mm) deep holes, one directly below the 1/4-20 tapped hole in the stainless steel bar.
7. Using the spacing from Table 1 in Section 2.2.1, make another 3/8" (10 mm) diameter, 1.25" (32 mm) deep hole perpendicular from the one made in the previous step.
8. Insert expansion anchors into the holes created in steps five and six with the slotted ends down.
9. Place the spacers on top of the anchors and attach the crackmeter that has rod end bearings to the anchors using the threaded rod, lock washer, and nuts provided.

Y-AXIS

The Y-axis monitors any movement perpendicular to the crack. It is mounted the same way in as the standard crackmeter installation, referenced in Section 2.2.4, with 3/8" diameter x 1 1/4" deep holes on each side of the crack, and at a spacing chosen from Table 1 in Section 2.2.1. Custom spacers are provided to be installed between the expansion anchors and the rod end bearings.

Perform the following installation steps:

1. Determine the proper setting distance using Table 1 in Section 2.2.1.
2. Using a masonry drill (or other suitable equipment), drill two 3/8 inch (10 mm) diameter holes, 1.25" (32 mm) deep at the proper locations.
3. Insert the expansion anchors into the holes, slotted end down.

4. Insert the provided setting tool into the anchor, small end first. Expand the anchor by hitting the large end of the setting tool with several sharp hammer blows.
5. Remove the PVC slotted sleeve or dowel pin securing the transducer shaft.
6. Push the cap screws through the swivel bearings and spacers on each end of the crackmeter and then tighten the cap screws into the anchors.
7. Check and record the reading with a portable readout.

Z-AXIS

The Z-axis, as shown above, measures vertical movement along the crack utilizing two brackets: one to transfer movement across the crack, and one to mount the sensor vertically. The 5-5/8" long stainless steel angle iron is mounted across the crack by installing an expansion anchor with a spacer approximately two inches from the break. The vertical element is then aligned so that a crackmeter with U-joints on both ends will be upright in relation to the break. Two expansion anchors are supplied with this part located 1-1/4" apart, and no spacers are required. A percentage of the transducer’s range can be established by tightening or loosening the nuts on the long threaded rod.

The actual height of the crackmeters above the surface is determined by the spacers and is proportional to the range of the sensor, to accommodate the maximum amount of movement.

The 3D hardware comes standard with expansion anchors, but is designed to be interchangeable with groutable anchors.

For installation steps, refer to the instructions in Section 2.2.3 for groutable anchors and Section 2.2.4 for drop-in expansion anchors.

D.3 MODEL 4420-3 CANTILEVER 3D ARRAY ALTERNATIVE

You can use the Model 4420-3 cantilever crackmeter to construct an alternative version of this 3D array, where the 4420-3 monitors the vertical Z-axis in a cantilever arrangement.

The 4420-3 employs a Model 4150 strain gauge to measure vertical movements. This version, shown below, is available in a one-inch range only.

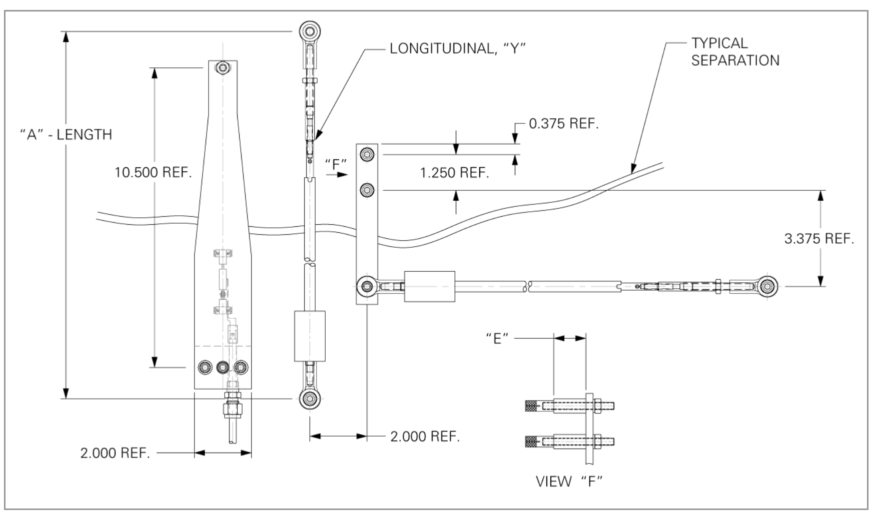

FIGURE 15: *Cantilever 3D Array - Top View*

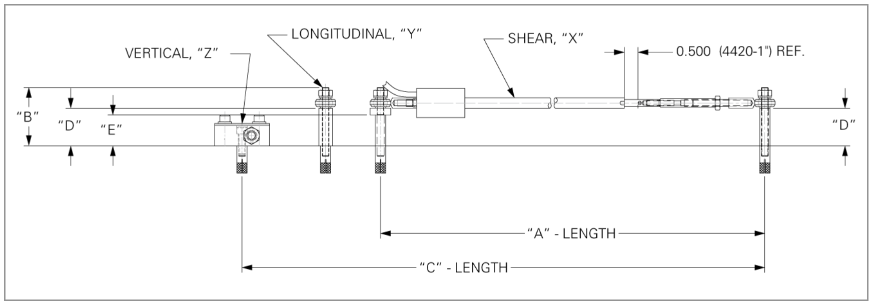

FIGURE 16: *Cantilever 3D Array - Front View*

Range	'A' Length @ Midrange	'B' Height	'C' Length	'D' Dimension	'E' Dimension
25 mm (1")	342.90 mm (13.50")	53.98 mm (2.125")	558.80 mm (22")	34.93 mm (1.375")	28.58 mm (1.125")

TABLE 10: *3D Array, Cantilever Version*

For detailed information about the 4420-3 low profile crackmeter, refer to Appendix E.

APPENDIX E. MODEL 4420-3 LOW PROFILE CRACKMETER

GEOKON Model 4420-3 low profile vibrating wire crackmeters use a Model 4150 strain gauge mounted to the underside of a stainless steel plate, an adjustable oval point set screw, and an instrument cable, which is secured and weatherproofed by a Swagelok connector.

The gauge is mounted as a cantilever, with the cable end of the crackmeter fixed to the mounting surface by a cap screw installed into an expansion anchor, with the opposite end left free. This free end allows the cone point set screw to maintain contact with the mounting surface (or reference disc) as it moves.

Strains are measured using the vibrating wire principle. As the mounting surface rises or falls, it increases or decreases the strain in the vibrating wire inside the 4150 gauge. This change in tension is measured as a change in the resonant frequency of vibration of the wire.

The threaded rod and accompanying jam nuts allow the zero reading to be adjusted as needed.

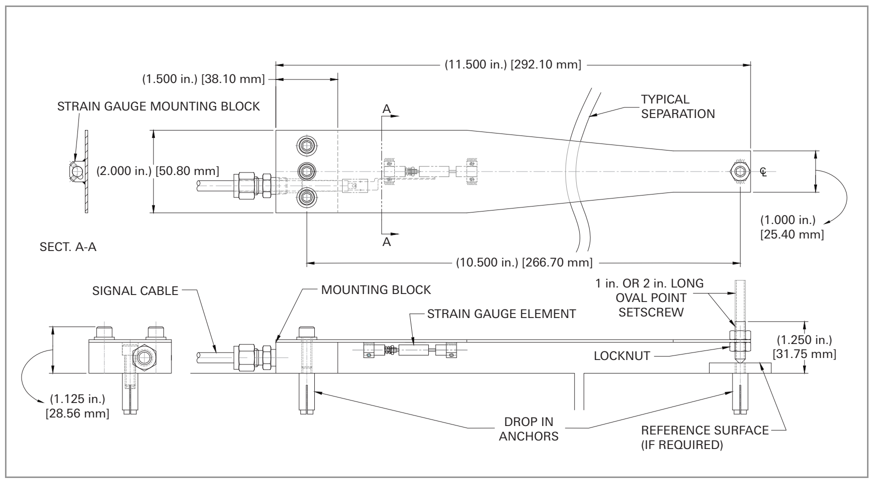

FIGURE 17: *Model 4420-3 VW Low Profile Crackmeter Layout*

E.1 INSTALLATION

E.1.1 PRELIMINARY TESTS

Perform a preliminary check by completing the following:

1. Connect the gauge to a readout box using the instructions in Section 4.1.
2. Observe the displayed readout, which usually will be between 1800 and 2500 digits. The temperature reading should match the ambient temperature.

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

Should any of these preliminary tests fail, see Section 6 for troubleshooting.

E.1.2 CRACKMETER INSTALLATION

1. Using a masonry drill (or other suitable equipment), drill a 3/8" (9.5 mm) diameter x 1.25" (32 mm) deep hole on each side of the crack, at a spacing of 10.5" (267 mm).

   Note: For mounting surfaces that are smooth in texture, the reference disc may be omitted. For installations without the reference disc only one hole and one expansion anchor is required. The completed assembly without a reference disc is shown in Figure 18 below.

2. Clean out the drill cuttings and insert the anchors into the holes, slotted end down.
3. Insert the provided setting tool, small end first, into each anchor. Expand the anchors by hitting the large end of the setting tool with several sharp hammer blows.
4. Using Loctite cement on the threads, screw the reference disc into one of the threaded expansion anchor holes until it is tight in the anchor.
5. Loosen the jam nuts on the oval point set screw. Using the wrench provided, back off the set screw so that it will not make contact with the reference surface when the gauge is mounted.

   Note: A one-inch set screw is provided for installations where 75% or more of the displacement is anticipated to move the reference surface up in relationship to the crackmeter. When using the one-inch set screw, the jam nuts should be placed on the underside of the gauge, space permitting.

6. Align the threaded hole on the cable side of the crackmeter over the other anchor.
7. Slide a washer over the supplied cap screw and tighten it into the expansion anchor.

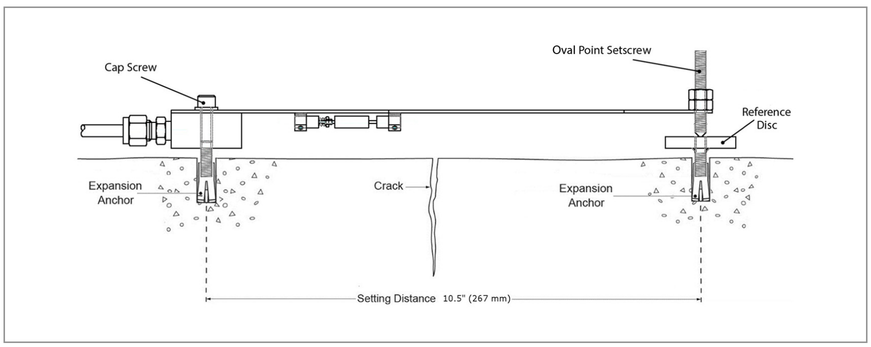

FIGURE 18: *Crackmeter assembly using reference disk and two anchors*

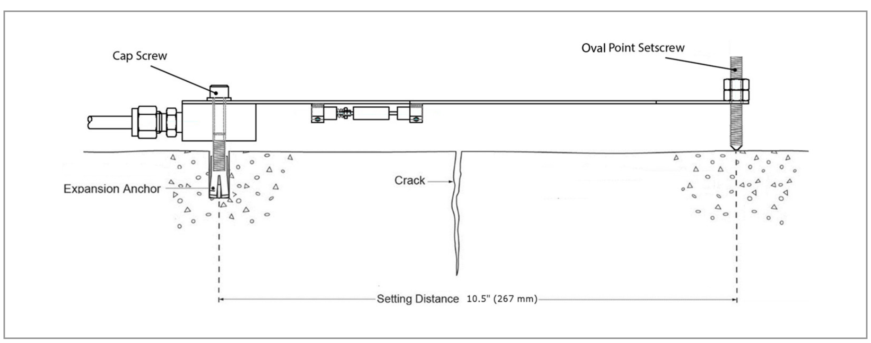

FIGURE 19: *Crackmeter assembly with only one anchor and without a reference disk*

8. Connect the cable to the readout box. Use the POS button to choose position E and the MODE button to select microstrain (με). The calibration sheet indicates the minimum and maximum readings recommended based on the setpoints utilized during the calibration process.
9. Set the zero position by turning the oval point set screw until the desired reading is achieved. The correct zero reading can be determined by the following:
   - If the set screw end of the gauge is anticipated to move up only in relationship to the 4150 gauge, set the zero reading near the 0.0 mm displacement according to the calibration sheet (about 2000 digits).
   - If the set screw end of the gauge is anticipated to only move down in relationship to the 4150 gauge, set the zero reading near the 25.4 mm displacement according to the calibration sheet (about 12,000 digits).
   - For unknown movement or to set the gauge at midrange, set the zero reading between the 10.2 mm and 15.2 mm displacement according to the calibration sheet (about 7000 digits).

   Note: The above zero reading suggestions are given assuming the two sides of the joint are on the same plane when the instrument is installed. If there is a major discrepancy between the two sides, contact geokon to determine if a custom solution is required.
10. Once the reading is set, tighten the locknuts to secure the set screw.
11. In areas of high traffic, the gauge should be protected by a cover plate. For more information, see Section 3.2.

E.2 SPECIFICATIONS

The table below lists the specifications.

Range:	3000 με
Resolution[1]	0.4 με
Calibration Accuracy	0.1% FS
System Accuracy[2]	2.0% FS
Stability:	0.1% / yr
Linearity:	2.0% FSR
Thermal Coefficient	12.2 με/°C
Temperature Range:	-20 to +80 °C -5 to +175 °F
Readout Position	E
Display Units	microstrain (με)
Frequency Range:	1400-3500 Hz
Coil Resistance:	+50Ω
Dimensions (gauge)	57.2 x 6.4 mm 2.250 x 0.250"
Dimensions (coil)	19.1 x 6.4 mm (diameter) 0.750 x 0.250" (diameter)
Mid-Range Reading	2500 με
Minimum Reading	1000 με
Maximum Reading	4000 με

TABLE 11: *Model 4420-3 Crackmeter Specifications*

Notes:

[1] Depends on the readout, above figure pertains to the GK-404 Readout.

[2] System Accuracy takes into account hysteresis, nonlinearity, misalignment, batch factor variations, and other aspects of the actual measurement program. System Accuracy to 1.0% FS may be achieved through individual calibration of each crackmeter.

E.3 THERMISTOR

Range: -80 to +150 °C

Accuracy: ±0.5 °C

E.4 TEMPERATURE CORRECTION FACTOR

A small correction can be made for change in temperature. As the temperature goes up the average reading of the sensor will go down approximately one digit per °C. To calculate the displacement, corrected for temperature, use the equation below.

$$D_{corrected} = G\,[(R_1 - R_0) + (T_1 - T_0)]$$

EQUATION 8: *Displacement, Corrected for Temperature*

The temperature effect shown above is for a low profile crackmeter that has not been installed yet and is very minor. The actual temperature effect of the installed instrument can be arrived at empirically only by simultaneous measurements of deformation and temperature over a short period of time.

GEOKON
48 Spencer Street
Lebanon, New Hampshire
03766, USA

Phone: +1 (603) 448-1562
Email: info@geokon.com
Website: www.geokon.com