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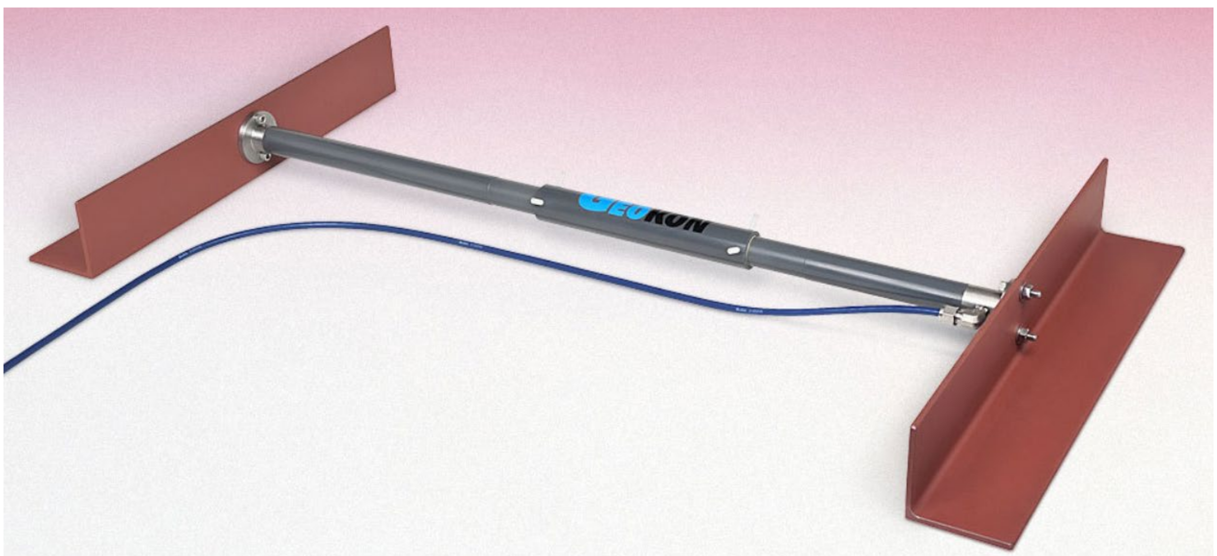
Instruction Manual

Model 4435

VW Soil Strainmeter



(Doc Rev G, 04/30/19)

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 which wear or which are damaged by misuse are not warranted. This includes fuses and batteries.

Geokon manufactures scientific instruments whose misuse is potentially dangerous. The instruments are intended to be installed and used only by qualified personnel. There are no warranties except as stated herein. There are no other warranties, expressed or implied, including but not limited to the implied warranties of merchantability and of fitness for a particular purpose. Geokon is not responsible for any damages or losses caused to other equipment, whether direct, indirect, incidental, special or consequential which the purchaser may experience as a result of the installation or use of the product. The buyer's sole remedy for any breach of this agreement by Geokon or any breach of any warranty by Geokon shall not exceed the purchase price paid by the purchaser to Geokon for the unit or units, or equipment directly affected by such breach. Under no circumstances will Geokon reimburse the claimant for loss incurred in removing and/or reinstalling equipment.

Every precaution for accuracy has been taken in the preparation of manuals and/or software, however, Geokon neither assumes responsibility for any omissions or errors that may appear nor assumes liability for any damages or losses that result from the use of the products in accordance with the information contained in the manual or software.

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1. INTRODUCTION

1.1 Theory of Operation

The Geokon Model 4435 Vibrating Wire Soil Strainmeter is designed to measure axial deformations in soil as might occur in dam embankments, levees, and highway fills, etc.

The basic sensing element is a vibrating wire strain gauge in series with a precision music wire spring. As the two end flanges of the Soil Strainmeter are pulled apart the tension in the spring and in the vibrating wire element increases. This change in tension alters the vibrational frequency of the vibrating wire element and this is measure by a readout box or datalogger and converted, by means of a calibration constant supplied, into an equivalent soil strain.

The Geokon Model 4435 Vibrating Wire Soil Strainmeters can be installed linked together in series to provide incremental deformation measurements over any length. Base lengths of the gauge can vary from a minimum of one meter to over 25 meters.

The internal spring and sensor are covered by an outer PVC tube, which is sealed by O-rings at the two flange ends and in the middle by a telescoping section of PVC tubing. The readout cable issues from the side of one of the end flanges. A thermistor is included for the measurement of temperatures.

Different combinations of gauge length and sensor range provide for optimum sensitivity. For maximum strain resolution, a long base gauge with a short-range transducer will give best results. For maximum deformation: short base length, longer transducer range. The flexibility of the system allows the user to choose the most useful combination of range and sensitivity according to predicted movements.

Readouts available from Geokon, used in conjunction with the Vibrating Wire Soil Strainmeter, will provide the necessary voltage pulses to pluck the wire and convert the measured frequencies to a displayed reading.

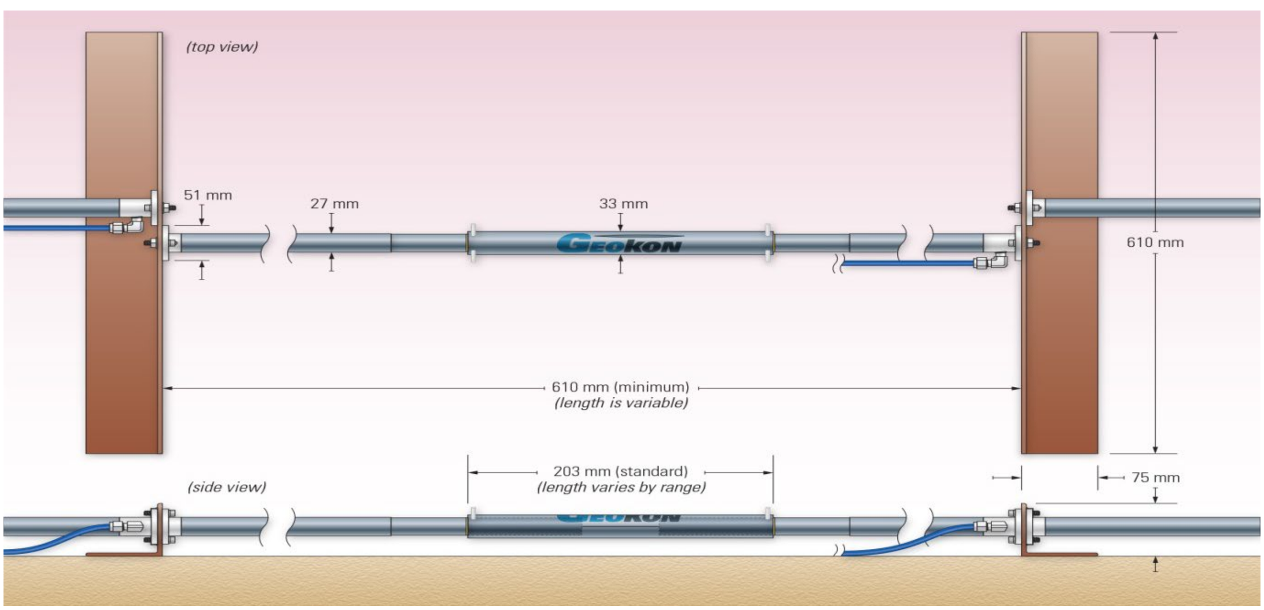


Figure 1 - Model 4435 Soil Strainmeter

2. INSTALLATION

2.1 Preliminary Tests

Upon receipt of the instrument, the gauge should be checked for proper operation (including the thermistor). In position "B" the gauge will read between 2000 and 8000 digits (see Section 3 for readout instructions). When pulling slightly on the end flanges (items number three and four in Figure 2), the reading should increase.

Checks of electrical continuity can also be made using an ohmmeter. Resistance between the gauge leads should be approximately 180Ω, ±10Ω. Remember to add cable resistance when checking. (22 AWG stranded copper leads have a resistance of approximately 14.7Ω per 1000 feet or 48.5Ω per kilometer. Multiply these factors by two to account for both directions.)

Resistance between the green and white conductors should be approximately 3000 ohms at 25 °C (see Table 6 in Appendix B for other temperatures), and between any conductor and the shield should exceed two megohms.

2.2 Installation in Fills and Embankments

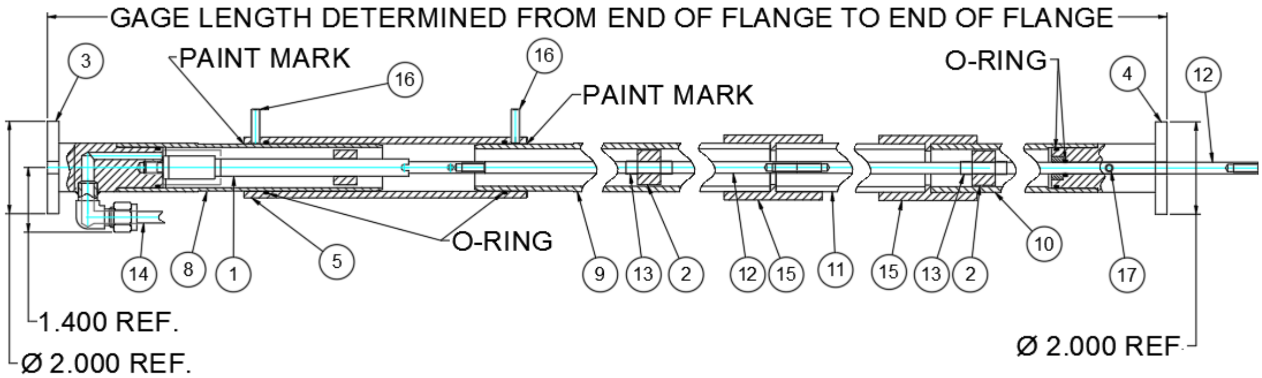
The Model 4435 Soil Strainmeter is installed in fills and embankments by placing the strainmeter sections in shallow, horizontal trenches in the fill. Multiple sensors can be installed in series to give a total deformation profile along a particular axis as in a dam or highway embankment.

A one-meter wide, flat bottom trench should be excavated in previously compacted fill. If the gauge has telescoping couplings, they should be held in a closed position while assembly is in process by means of two nylon screws. These screws should be slackened when the assembled sensors are in their final locations.

Multiple sensors are linked together by means of the (75 mm x 75 mm) flanges provided. The sensors are bolted to the flanges and the coiled readout cables are laid alongside the tubing. When all the sensor sections are in place the cables are strung out in the trench the trench is then backfilled with material which has had any large (>10 mm, 0.5") aggregate removed. Backfill and hand tamp the first 15 cm (≈6") and then proceed with the compaction of the fill in the normal way.

Depending on the gauge length and range of the transducer, the sensor may arrive fully assembled or it may need to be assembled on site. The use of one or multiple telescoping couplings may be required depending on gauge length of the transducer. Section 2.3 describes the procedure to assemble sensors in the field.

2.3 Sensor assembly



ITEM	DESCRIPTION
17	SETSCREW #8-32 X ¼ " LG. (OVAL POINT)
16	NYLON SETSCREW #10-32 X ¾ " LG.
15	¾ " SCH. 80 SOC X SOC COUPLING
14	SIGNAL CABLE
13	3M, SUPPER 88 BLACK ELECTRICAL TAPE
12	CONNECTING ROD
11	STD. PIPE
10	SHAFT END FLANGE TO COUPLING TUBE
9	COUPLING TO SLIP JOINT TUBE
8	FLANGE TO SLIP JOINT TUBE
7	"O"-RING BULLET (SHOWN DETACHED)
6	SHIPPING TUBE (SHOWN DETACHED)
5	SLIP JOINT
4	SHAFT END FLANGE W/ HOLES
3	CABLE FLANGE WITH ELBOW
2	SPACER
1	V.W. TRANSDUCER, 50MM (2 ") RANGE

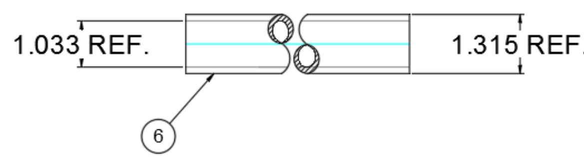


Figure 2 - 4435 Print

Complete the following:
(Item numbers referenced in the following steps are detailed in Figure 2.)

1) Remove the 1.315” *shipping tube* (Item 6) from the back of the transducer and discard. At this point, the shipping spacer, or shipping pin, can be removed and the push rod can be gently retracted back into the transducer. Perform preliminary tests on the sensors to verify proper operation (Section 2.1).

2) Install a length of flush-coupled *connecting rod* (Item 12) into the threaded rod of the transducer. Use a thread locker if available. Caution: When threading the connecting rod into the push rod of the transducer, ensure the pin of the pushrod is fully engaged in the slot of the transducer tube to prevent rotation of internal components.

3) Slide the *slip joint* (Item 5) over the connecting rod and transducer until the end aligns with the paint mark located on the *flange to slip joint tube* (Item 8). Tighten the nylon set screws (Item 16) to maintain this position.

4) *Spacers* (Item 2) should be installed along the connecting rod at 3' (one meter) intervals to prevent the rod from flexing in the tube. This is done by locating the spacer in its approximate location and wrapping tape around the connecting rod on both sides of the spacer using the provided *electrical tape* (Item 13).

5) Install the *coupling to slip joint tube* (Item 9) into the slip joint until the painted mark aligns with the other side of the slip joint and tighten the *nylon set screws* (Item 16). Note: depending on the gauge length, this tube may couple directly to the *shaft end flange* (Item 4).

6) For longer gauge lengths, couplings and standard pipes are provided. Use PVC cement to affix a *coupling* (Item 15) to the slip joint to coupling tube. On the other side of the coupling, cement a length of *standard pipe* (Item 11). Continue to add couplings, tubes, spacers, and connecting rod until there is only the shaft end flange to connect.

7) Attach the provided *o-ring bullet* (Item 7) to the final length of connecting rod. This will allow the shaft end flange to be slid over the connecting rod without damaging the internal o-rings. PVC cement the *shaft end flange to coupling tube* (Item 10) to the final coupling. The o-ring bullet can now be removed and used with other assemblies.

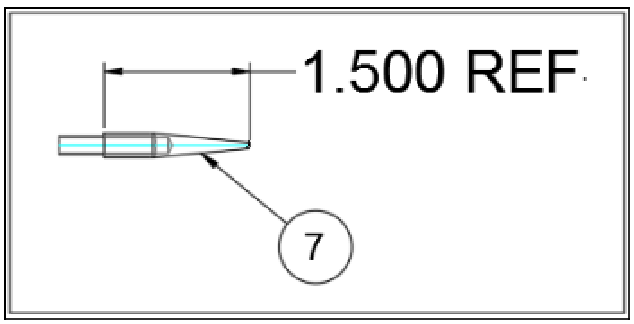


Figure 3 - O-ring Bullet

8) At this point, the gauge length should be established. If minor adjustments are needed, the nylon set screws in the slip joint can be loosened and either end adjusted to the proper distance. Note: The assembly should only be adjusted by half the range of the sensor in either direction from the painted mark.

9) To set the range of the transducer, take the end of the *connecting rod* (Item 12) protruding out the back of the flange and pull it to the desired percentage of the range, either by measuring the distance the rod was pulled, or by recording the reading of the sensor while pulling on the connecting rod (preferred method). Make sure not to overextend the rod or rotate it beyond 180 degrees as this may damage the sensor. Tighten the *setscrews* (Item 17) in the rod end flange to lock the sensor's position in place. Any excess rod protruding out of the back can be sawed off at this point, if needed.

10) Install the assembly, and then loosen the nylon setscrews. Take baseline zero readings for comparison.

2.4 Cable Installation and Splicing

The cable should be routed to minimize the possibility of damage due to moving equipment, debris or other causes. The cable can be protected using flexible conduit, which can be supplied by Geokon.

Terminal boxes with sealed cable entries are available from Geokon for all types of applications. These allow many gauges 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 gauge 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, which 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.

Cables may be terminated by stripping and tinning the individual conductors and then connecting them to the patch cord of a readout box. Alternatively, a connector may be used which will plug directly into the readout box or to a receptacle on a special patch cord.

2.5 Initial Readings

All readings are referred to an initial reading. It is important that this initial reading be carefully taken. Conditions should be noted at the time of all readings, especially during curing, e.g., temperature, time after placement, local conditions, etc.

2.6 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.

2.7 Lightning Protection

The Model 4435 Vibrating Wire Soil Strainmeter, unlike numerous other types of instrumentation available from Geokon, does 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 deformation meter and possibly destroy it.

Note the following suggestions:

- If the gauge 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 Geokon provide locations for installation of these components.

- Lighting arrestor boards and enclosures are available from Geokon that install near the instrument. The enclosure has a removable top. If 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 gauge. See Figure 4. Consult the factory for additional information on these or alternate lightning protection schemes.

- Plasma surge arrestors can be epoxy potted into the gauge cable close to the sensor. A ground strap would connect the surge arrestor to earth ground; either a grounding stake or other suitable earth ground.

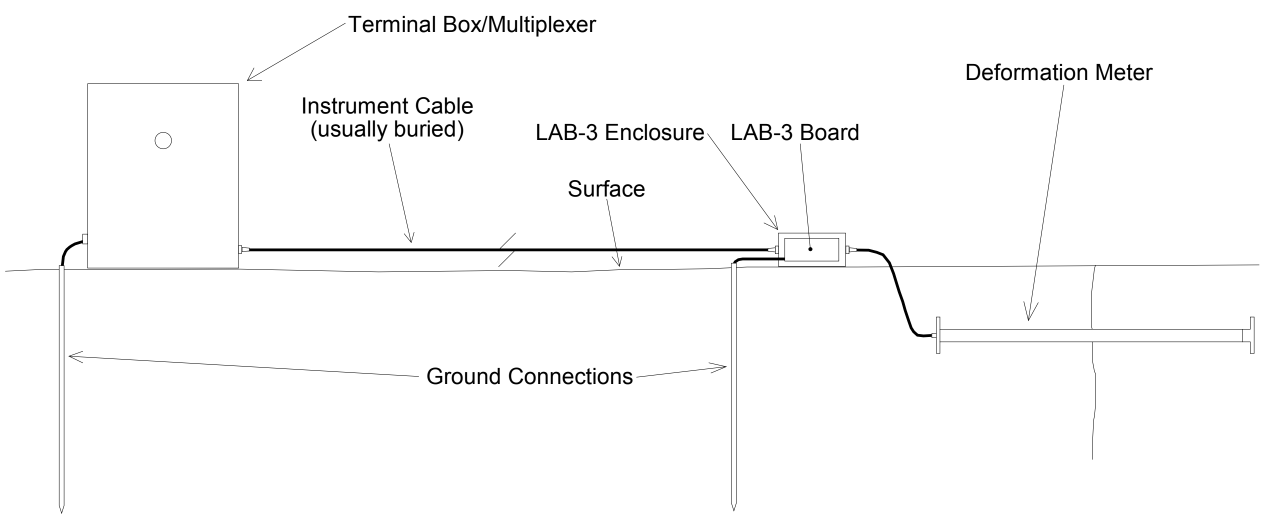


Figure 4 - Lightning Protection Scheme

3. TAKING READINGS

3.1 GK-404 Readout Box

The Model GK-404 Vibrating Wire Readout is a portable, low-power, handheld unit that can run continuously for more than 20 hours on two AA batteries. It is designed for the readout of all Geokon vibrating wire gauges and transducers; and is capable of displaying the reading in either 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.

3.1.1 Operating the GK-404

Before use, attach the flying leads to the GK-404 by aligning the red circle on the silver "Lemo" connector of the flying leads with the red line on the top of the GK-404 (Figure 5). Insert the Lemo connector into the GK-404 until it locks into place.

Figure 5 - Lemo Connector to GK-404

Connect each of the clips on the leads to the matching colors of the sensor conductors, with blue representing the shield (bare).

To turn the GK-404 on, press the "ON/OFF" button on the front panel of the unit. The initial startup screen will be displayed.

After approximately one second, 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 letter 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 gauge in degrees Celsius.

Use the **POS** button to select position **B** and the **MODE** button to select **Dg** (digits). (Other functions can be selected as described in the GK-404 Manual.)

The GK-404 will continue to take measurements and display readings until the unit is turned off, either manually, or if enabled, by the Auto-Off timer. If the no reading displays or the reading is unstable, see Section 5 for troubleshooting suggestions.

For further information, please refer to the GK-404 manual.

3.2 GK-405 Readout Box

The GK-405 Vibrating Wire 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; and the GK-405 Remote Module, which is housed in a weatherproof enclosure and connects to the vibrating wire gauge to be measured. The two components communicate wirelessly. The Readout Unit can operate from the cradle of the Remote Module, or, if more convenient, can be removed and operated up to 20 meters from the Remote Module.

3.2.1 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.

3.2.2 Connecting Sensors with Bare Leads

Attach the GK-403-2 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).

3.2.3 Operating the GK-405

Press the button labeled “POWER ON”. A blue light will begin blinking, signifying that the Remote Module is waiting to connect to the handheld unit. Launch the GK-405 VWRA program by tapping on “Start” from the handheld PC’s main window, then “Programs” then the GK-405 VWRA icon. After a few seconds, the blue light on the Remote Module should stop flashing and remain lit. The Live Readings Window will be displayed on the handheld PC. Figure 6 shows a typical vibrating wire sensor output in digits and thermistor output in degrees Celsius. If the no reading displays or the reading is unstable, see Section 5 for troubleshooting suggestions.

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

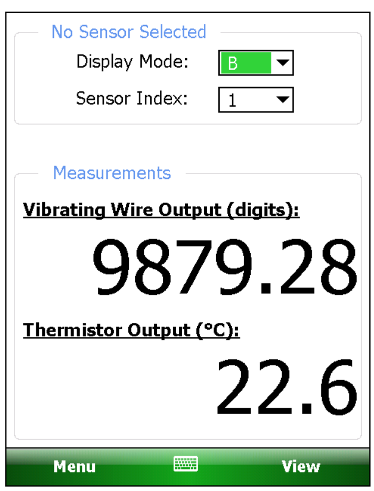


Figure 6 - Live Readings – Raw Readings

3.3 GK-403 Readout Box (Obsolete Model)

The GK-403 can store gauge readings and apply calibration factors to convert readings to engineering units. The following instructions explain taking gauge measurements using Mode “B”. Consult the GK-403 Instruction Manual for additional information.

3.3.1 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.

3.3.2 Connecting Sensors with Bare Leads

Attach the GK-403-2 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).

3.3.3 Operating the GK-403

1) Turn the display selector to position “B”.
2) Turn the unit on.
3) The readout will display the vibrating wire output in digits. The last digit may change one or two digits while reading. (See Section 4 for data reduction.)
4) The thermistor reading will be displayed above the gauge reading in degrees centigrade.
5) Press the “Store” button to record the value displayed.

If the no reading displays or the reading is unstable, see Section 5 for troubleshooting suggestions.

The unit will automatically turn off after approximately two minutes to conserve power.

3.4 Measuring Temperatures

All vibrating wire transducers are equipped with a thermistor, which 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-403, GK-404, and GK-405 readout boxes will read the thermistor and display the temperature in degrees Celsius.

To read temperatures using an ohmmeter:

Connect an ohmmeter to the green and white leads of the cable. Look up the temperature for the measured resistance in Appendix B, Table 6. (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 14.7 Ω for every 1000 ft., or 48.5Ω per km at 20 °C. Multiply these factors by two to account for both directions.)

4. DATA REDUCTION

4.1 Deformation Calculation

The basic units utilized by Geokon for measurement and reduction of data from Vibrating Wire Deformation Meters are "digits". The units displayed by all Readout Boxes in position "B" are digits. Calculation of digits is based on the following equation:

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

Equation 1 - Digits Calculation

To convert digits to deformation the following equation applies:

Deformation = (Current Reading - Initial Reading) × Calibration Factor × Conversion Factor

Or

$$D = (R_1 - R_0) \times G \times F$$

Equation 2 - Deformation Calculation

Where;
R_1 is the Current Reading.
R_0 is the Initial Reading usually obtained at installation (see Section 2.5).
G is the Calibration Factor, usually in terms of millimeters or inches per digit.
F is an engineering units conversion factor (optional), see Table 1.

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 1 - Engineering Units Conversion Multipliers

For example, taken from the typical Calibration Sheet shown in Figure 7, the Initial Reading (R_0) at installation of a deformation meter with a 25 mm transducer range is 4250 digits. The Current Reading (R_1) is 6785. The Calibration Factor is 0.004457 mm/digit. The deformation change is:

$$D = (6785 - 4250) \times 0.004457 = +11.4 \text{ mm}$$

Note that increasing readings (digits) indicate increasing extension.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Vibrating Wire Displacement Transducer Calibration Report

Range: 25 mm

Calibration Date: September 01, 2005

Serial Number: 05-8389

Temperature: 23.6 °C

Cal. Std. Control Numbers: 529, 406, 344, 057

Calibration Instruction: CI-4400 Rev: C

Technician: Erica

GK-401 Reading Position B

Actual Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Displacement (Linear)	Error Linear (%FS)	Calculated Displacement (Polynomial)	Error Polynomial (%FS)
0.0	2230	2228	2229	-0.055	-0.22	-0.008	-0.03
5.0	3369	3368	3369	5.024	0.10	5.014	0.06
10.0	4494	4492	4493	10.04	0.14	9.999	0.00
15.0	5615	5613	5614	15.03	0.13	15.00	-0.02
20.0	6729	6729	6729	20.00	0.01	19.99	-0.03
25.0	7841	7841	7841	24.96	-0.17	25.01	0.02

(mm) Linear Gage Factor (G): 0.004457 (mm/ digit) **Regression Zero: 2241**

Polynomial Gage Factors: A: 1.11026E-08 B: 0.004345 C: -9.7486

(inches) Linear Gage Factor (G): 0.0001755 (inches/ digit)

Polynomial Gage Factors: A: 4.37111E-10 B: 0.0001711 C: -0.38380

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

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

Refer to manual for temperature correction information.

Function Test at Shipment:

GK-401 Pos. B : 4795 Temp(T_0): 23.7 °C Date: September 19, 2005

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.
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Figure 7 - A Typical Calibration Sheet

4.2 Temperature Correction

The Model 4435 Deformation Meter has a very small coefficient of thermal expansion; therefore, 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. The following equation applies:

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

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.
L_C is the correction for the gauge length.

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:

$$\text{Thermal Coefficient} = ((\text{Reading in Digits} \times \text{Multiplier}) + \text{Constant}) \times \text{Calibration Factor}$$

Or

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

Equation 4 - Thermal Coefficient Calculation

See Table 2 for the Multiplier and Constant values used in Equation 4. The Multiplier (M) and Constant (B) values vary for the stroke of the transducer used in the Deformation Meter.

Model:	4435- 25 mm (1")	4435- 50 mm (2")	4435- 100 mm (4")	4435- 150 mm (6")	4435- 200 mm (8")	4435- 300 mm (12")
Multiplier (M):	0.000369	0.000376	0.000398	0.000384	.000396	0.000424*
Constant (B):	0.572	0.328	0.0864	-0.3482	-0.4428	-0.6778*
Transducer Length (L):	206 mm 8.1"	272 mm 10.7"	409 mm 16.1"	474 mm 18.7"	672 mm 26.5"	939 mm 37.0"

Table 2 - Thermal Coefficient Calculation Constants

* Calculated

The gauge length correction (L_C) is calculated using Equation 5.

$$L_C = 17.3 \times 10^{-6} \times L \times (T_1 - T_0)$$

Equation 5 - Gauge Length Correction

Where L is the length of deformation meter in millimeters or inches, minus the transducer length (see Table 2), in millimeters or inches, respectively.

Consider the following example using a Model 4435 Deformation Meter with a one-meter gauge length and 25 mm transducer. Taken from the calibration sheet shown in Figure 7:

$R_0 = 4250$ digits
$R_1 = 6785$ digits
$T_0 = 10$ °C
$T_1 = 20$ °C
$G = 0.004457$ mm/digit
$K = ((6785 \times 0.000369) + 0.572) \times 0.004457 = 0.0137$
$L = 1000 - 267 = 733$
$L_C = 17.3 \times 10^{-6} \times 733 \times (20 - 10) = 0.1268$
$D_{corrected} = ((R_1 - R_0) \times G) + ((T_1 - T_0) \times K) + L_C$
$D_{corrected} = ((6785 - 4250) \times 0.004457) + ((20 - 10) \times 0.0137) + 0.1268$
$D_{corrected} = (2535 \times 0.004457) + (10 \times 0.0137) + 0.1268$
$D_{corrected} = 11.298 + 0.137 + 0.1268$
$D_{corrected} = +11.56$ mm

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

4.3 Environmental Factors

Since the purpose of the Soil Strainmeter 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 deformation meters is confined to periodic checks of cable connections and maintenance of terminals. Once installed, the gauges are usually inaccessible and remedial action is limited. **Gauges should not be opened in the field.** Should difficulties arise, consult the following list of problems and possible solutions. Return any faulty gauges to the factory. For additional troubleshooting and support, contact Geokon.

Symptom: Thermistor resistance is too high

- ✓ It is likely that there is an open circuit. Check all connections, terminals, and plugs. If a cut is located in the cable, splice according to instructions in Section 2.4.

Symptom: Thermistor resistance is too low

- ✓ It is likely that there is a short. Check all connections, terminals, and plugs. If a short is located in the cable, splice according to instructions in Section 2.4.

- ✓ Water may have penetrated the interior of the transducer. 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 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 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 whether using a portable readout or datalogger. Connect the shield drain wire to the readout using the blue clip. (Green for the GK-401.)

- ✓ Does the readout work with another gauge? If not, it may have a low battery or possibly be malfunctioning.

Symptom: Instrument Fails to Read

- ✓ Is the cable cut or crushed? Check the resistance of the cable by connecting an ohmmeter to the gauge leads. Table 3 shows the expected resistance for the various wire combinations; Table 4 is provided for the user to fill in the actual resistance found. Cable resistance is approximately 14.7Ω per 1000 feet of 22 AWG wire. Multiply this factor by two to account for both directions. If the resistance is very high or infinite (megohms), the cable is probably broken or cut. If the resistance is very low (<20Ω), the gauge conductors may be shorted. If a cut or a short is located in the cable, splice according to the instructions in Section 2.4.

- ✓ Does the readout or datalogger work with another gauge? If not, it may have a low battery or possibly be malfunctioning.

Vibrating Wire Sensor Lead Grid - SAMPLE VALUES					
	Red	**Black**	**White**	**Green**	**Shield**
Red	N/A	≅180Ω	infinite	infinite	infinite
Black	≅180Ω	N/A	infinite	infinite	infinite
White	infinite	infinite	N/A	3000Ω at 25°C	infinite
Green	infinite	infinite	3000Ω at 25°C	N/A	infinite
Shield	infinite	infinite	infinite	infinite	N/A

Table 3 - Sample Resistance

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

Table 4 - Resistance Work Sheet

APPENDIX A. SPECIFICATIONS

A.1 Model 4435 Deformation Meter

Strainmeter Length:[1]	Variable (1 m /40" standard).
Ranges Available:[1]	12, 25, 50, 100, 150, 300 mm 0.5, 1, 2, 4, 6, 12"
Overrange:	115%
Accuracy:	0.1% (with polynomial expression)
Resolution:	0.025% FSR
Linearity:	0.25% FSR
Thermal Zero Shift:	< 0.05% FSR/°C
Stability:	< 0.2%/yr (under static conditions)
Temperature Range:	-20 to +80 °C
Frequency Range:	1200 - 2800 Hz
Coil Resistance:	180 Ω, ±10 Ω
Cable Type:[2]	Two twisted pair (four conductor) 22 AWG Foil shield, PVC jacket, nominal OD=6.3 mm (0.250")
Diameter:	26.7 mm, 1.050" (body), 33 mm (telescoping section) 51 mm, 2" (flange)
Flange:	610 x 75 x 75 mm (3 x 3 x 24 inch)
Weight:	1 kg., 2.2 lbs. (Standard one-meter length)

Table 5 - Model 4435 Specifications

Notes:
[1] Consult the factory for other lengths and ranges available.
[2] Consult the factory for alternate cable types.

A.2 Thermistor (see Appendix B also)

Range: -80 to +150 °C
Accuracy: ±0.5 °C

APPENDIX B. THERMISTOR TEMPERATURE DERIVATION

Thermistor Type: YSI 44005, Dale #1C3001-B3, Alpha #13A3001-B3
Resistance to Temperature Equation:

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

Equation 6 - Resistance to Temperature

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	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 6 - Thermistor Resistance versus Temperature