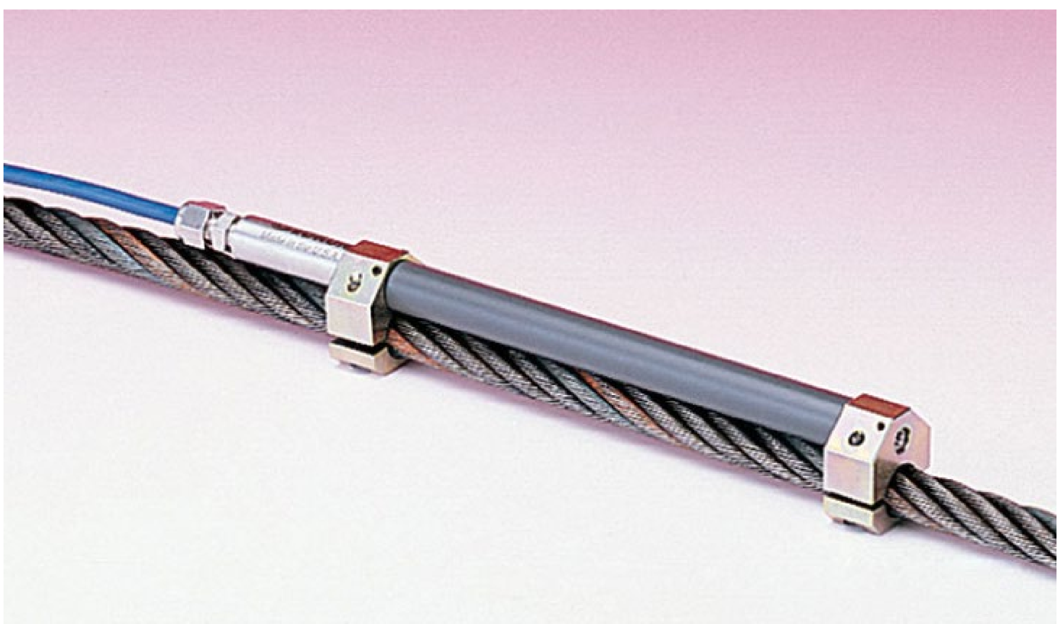
GEOKON®

48 Spencer Street
Lebanon, NH 03766, USA
Tel: 603·448·1562
Fax: 603·448·3216
Email: geokon@geokon.com
http://www.geokon.com

Instruction Manual

Model 4410

Vibrating Wire Strandmeter



(Doc Rev O, 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.

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1. INTRODUCTION

1.1 Theory of Operation

The Geokon Vibrating Wire Strandmeter is designed to measure change in deformation in wire strands such as those that are commonly used in tiebacks and earth anchors.

The instrument consists of a vibrating wire sensing element in series with a heat treated, stress relieved spring which is connected to the wire at one end and a connecting rod at the other. The unit is fully sealed and operates at pressures of up to 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 tension in the wire is directly proportional to the extension; hence, the change in deformation can be determined very accurately by measuring the strain change with the vibrating wire readout box.

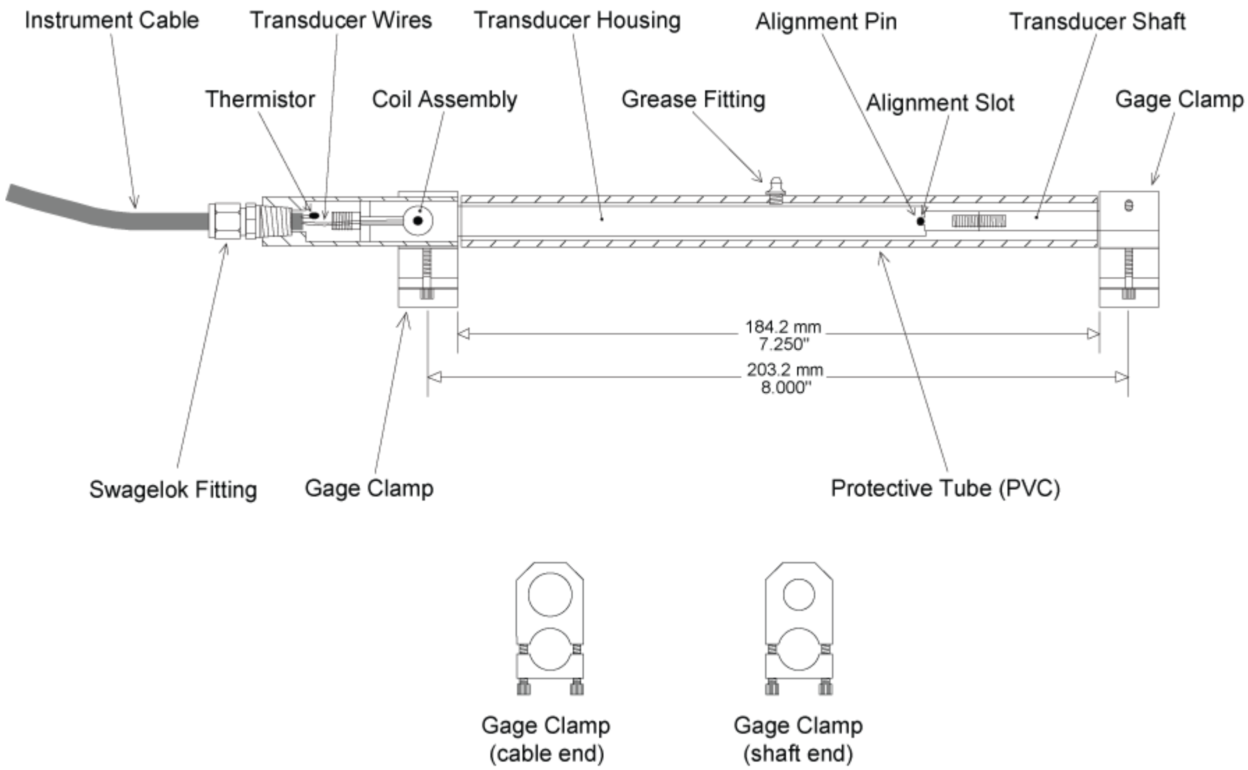

Figure 1 - Model 4410 Vibrating Wire Strandmeter

2. INSTALLATION

2.1 Preliminary Tests

Upon receipt of the instrument, the gauge should be checked for proper operation (including the thermistor). See Section 3 for readout instructions. When the shaft is fully retracted, the vibrating wire is slack and may give an erratic reading. This is normal. Extending the shaft very slightly the vibrating wire is put in tension and, in position B on the readout, the gauge will read around 1500 to 2000 digits.

CAUTION! Do not rotate the transducer shaft beyond 180 degrees or extend it beyond the range of the gauge (a reading of about 8000 digits).

Checks of electrical continuity can also be made using an ohmmeter. Resistance between the gauge leads should be approximately 150Ω, ±10Ω. Remember to add cable resistance when checking (22 AWG stranded copper leads are approximately 14.7Ω/1000' or 48.5Ω/km, multiply by two for both directions). Between the green and white should be approximately 3000 ohms at 25 °C (see Appendix B), and between any conductor and the shield should exceed two megohms.

2.2 Strandmeter Installation

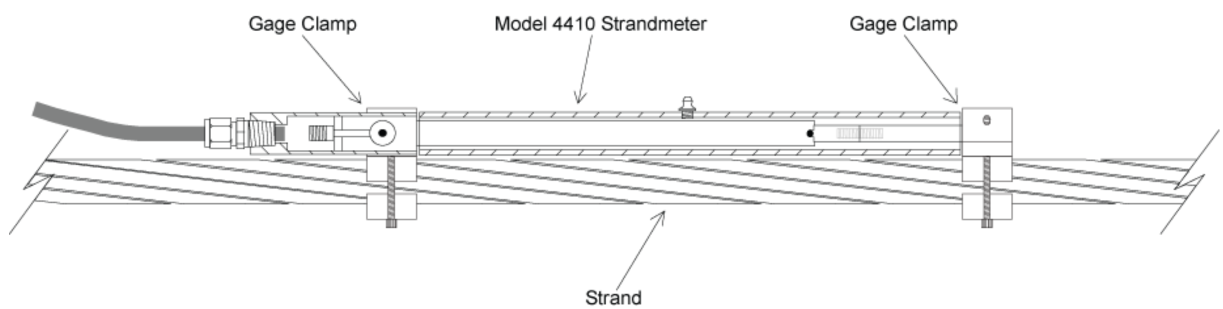

Figure 2 - Model 4410 Strandmeter Installation

Note: References to the PVC grease tube in the following instructions are for strandmeters used on strands that are to be embedded in concrete. For strands out in the open, the grease tube may be omitted.

Strandmeter installation is as follows:

1) Unbolt and separate the two halves of the clamps.

2) Slide the upper half of the clamp with the large hole around the strand meter so that the coil housing sits up against the shoulder in the clamp recess.

3) Slide the PVC grease tube over the strandmeter and then the upper half of the clamp with the small hole over the shaft end of the strandmeter.

4) Place the assembly down so that the bottoms of the two clamps sit on a flat surface.

5) Take the spacer bar and position it between the clamps. Make sure that the coil housing is against the shoulder in the clamp, snug the two clamps up to the spacer bar.

6) Tighten the four 6-32 set screws holding the strandmeter to the two clamps.

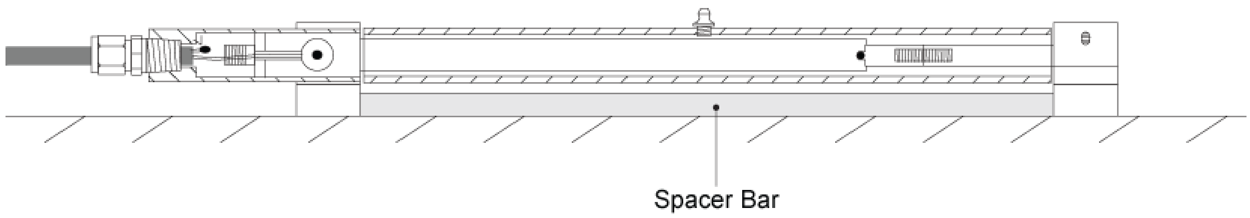

Figure 3 - Spacer Bar Position

7) Remove the spacer bar and place the assembly in the correct location over the strand.

8) Tighten the lower half of the clamps onto the strand using the four cap screws.

9) Set the zero reading of the gauge by completing the following:
    a. Loosen the two 6-32 set screws that hold the clamp to the strandmeter shaft.
    b. Insert a 10-32 screw (supplied) into the end of the shaft that comes through the clamp.
    c. Connect the gauge leads to the readout box (see Section 3) and switch to position 'B'.
    d. While watching the reading on the readout, gently pull on the 10-32 screw until an increasing reading is seen. **Do not allow the reading to reach 8000.**
    e. While holding the reading between 2500-4000 (3000 is recommended), tighten the two 6-32 set screws using the Allen wrench provided. Tighten them down hard, so that the gauge will not move.
    f. Tighten the 6-32 set screws on the other clamp as well.

10) For strands that are to be embedded in concrete, fill the PVC tube with grease. A 1/4-28 threaded hole (Figure 1) is provided which will accept a standard grease fitting. Screw the fitting into the hole, fill with grease, and then remove the fitting.

11) For embedded strandmeters, it is necessary to provide the clamps with a bond breaker. Using the Aqua-Seal provided, place a layer over the clamp areas on both ends followed by an overall layer of electrical tape. The purpose of this is to isolate the sensor from stresses other than those imposed by the tendon.

12) 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.

2.3 Electrical Noise

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

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 by the use of 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 Lightning Protection

The Model 4410 Vibrating Wire Strandmeter, 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 gauge 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. In the event the protection board (LAB-3) is damaged, the user may service the components (or replace the board). A connection is made between this enclosure and earth ground to facilitate the passing of transients away from the 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 such as perhaps the strand to which the transducer is attached.

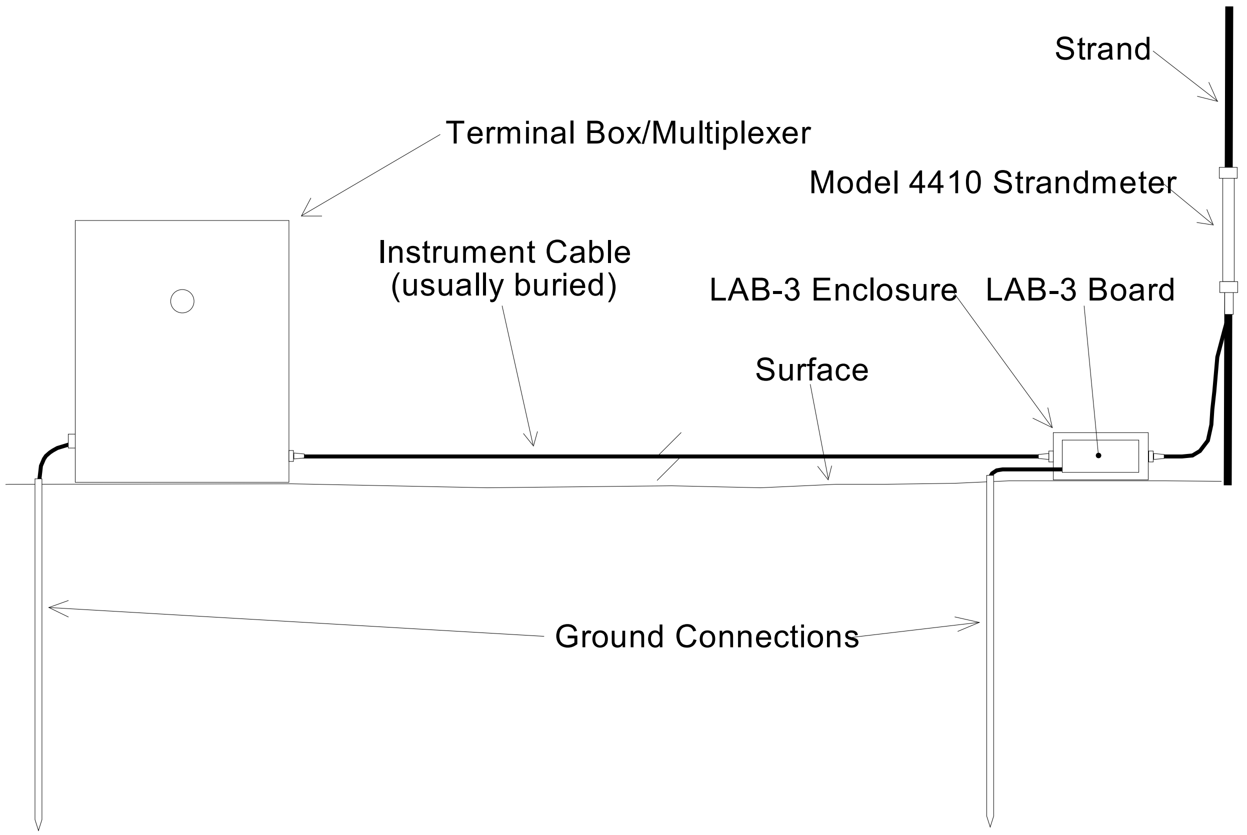

Figure 4 - Lightning Protection Scheme

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

For further information, consult 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 via a cable 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

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.

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).

3.2.2 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. Choose display mode “B”.

Figure 6 shows a typical vibrating wire output in digits and thermistor output in degrees Celsius.

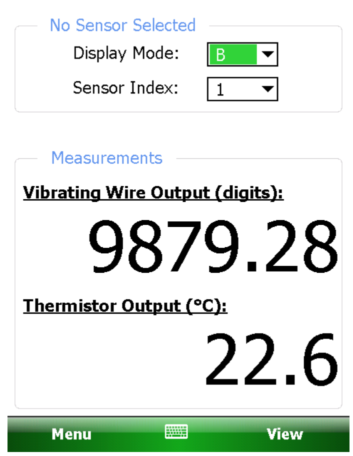

Figure 6 - Live Readings – Raw Readings

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

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".

3.3.1 Connecting Sensors to the GK-403

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.

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).

3.3.2 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.

4) The thermistor reading will be displayed above the gauge reading in degrees centigrade.

5) Press the "Store" button to record the value displayed.

The unit will automatically turn off after approximately two minutes to conserve power. Consult the GK-403 Instruction Manual for additional information.

3.4 Measuring Temperatures

All vibrating wire strandmeters 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 C.

To read temperatures using an ohmmeter: Connect an ohmmeter to the green and white thermistor leads coming from the strandmeter. 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 per 1000 ft. / 48.5Ω per km at 20 °C. Multiply these factors by two to account for both directions. Look up the temperature for the measured resistance in Appendix B, Table 5.

4. DATA REDUCTION

4.1 Deformation Calculation

The basic units utilized by Geokon for measurement and reduction of data from Vibrating Wire strandmeters 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;
D is the Deformation in millimeters or inches.
R_1 is the Current Reading.
R_0 is the Initial Reading usually obtained at installation.
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, the Initial Reading (R_0) at installation of a strandmeter is 4783 digits. The Current Reading (R_1) is 5228. The Calibration Factor is 0.0006194 mm/digit. The deformation change is $D = (5228 - 4783) \times 0.0006194 = +0.2756$ mm

Note that increasing readings (digits) indicate increasing extension.
A typical Calibration Sheet for a three-millimeter range strand meter is shown on the next page.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Displacement Transducer Calibration Report

Range: 3 mm

Serial Number: 1639381

Calibration Instruction: CI-4400

Cable Length: 20 meters

Calibration Date: December 22, 2016

This calibration has been verified/validated as of 11/13/2017

Temperature: 20.3 °C

Technician: Kathy Rogers

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	2740	2741	2741	0.00	-0.12	0.00	0.01
0.6	3510	3507	3509	0.60	0.02	0.60	-0.01
1.2	4276	4271	4274	1.20	0.08	1.20	-0.02
1.8	5039	5036	5038	1.80	0.11	1.80	0.01
2.4	5798	5798	5798	2.40	0.06	2.40	0.03
3.0	6553	6553	6553	3.00	-0.15	3.00	-0.02

(mm) Linear Gage Factor (G): 0.0007867 **(mm/ digit)** **Regression Zero:** 2745

Polynomial Gage Factors: **A:** 2.004E-09 **B:** 0.0007680 **C:** ______

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

(inches) Linear Gage Factor (G): 0.00003097 **(inches/digit)**

Polynomial Gage Factors: **A:** 7.8898E-11 **B:** 0.00003024 **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 7 - Typical Strandmeter Calibration Report

4.2 Strain Calculation

The gauge length of the standard strand meter is 203.2 mm, (eight inches). The strain in **microstrains μ** is given by the equations:

Where D is in mm: $\mu = (D/203.2) \text{ x } 10^6$ microstrain

Equation 3 - Strand Calculation in Millimeters

Where D is in inches: $\mu = (D/8) \text{ x } 10^6$ microstrain

Equation 4 - Strand Calculation in Inches

4.3 Temperature Correction

The Model 4410 Vibrating Wire Strandmeters have a small coefficient of thermal expansion; therefore, in many cases correction is not necessary. However, if maximum accuracy is desired or the temperature changes are large corrections may be applied. The temperature coefficient of the strand to which the Strandmeter is attached should also be taken into account. By correcting the transducer readings for temperature, changes the temperature effect on the strand can be isolated and quantified.

The following equation applies:

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

Equation 5 - 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 for the Transducer, (see Equation 6).

Tests have determined that the Thermal Coefficient, K, changes with the position of the transducer shaft. Hence, the first step in the temperature correction process is determination of the proper Thermal Coefficient based on the following equation:

$$\text{Thermal Coefficient} = (\text{Reading in Digits} \times 0.000520) + 3.567) \times \text{Calibration Factor}$$

Or

$$K = ((R_1 \times 0.000520) + 3.567) \times G$$

Equation 6 - Thermal Coefficient Calculation

Where;
R_1 is the Current Reading.
G is the Calibration Factor supplied with the instrument.

Consider the following example using a Model 4410-5 mm Strandmeter:

R_0 = 4783 digits
R_1 = 5228 digits
T_0 = 15.8° C
T_1 = 27.2° C
G = 0.0006194 mm/digit
K = ((5228 × 0.000520) + 3.567) × 0.0006194 = 0.00389
Dcorrected = ((R_1 - R_0) × G) + ((T_1 - T_0) × K)
Dcorrected = ((5228 - 4783) × 0.0006194) + ((27.2 - 15.8) × 0.00389)
Dcorrected = (445 × 0.0006194) + 0.04435
Dcorrected = 0.2756 + 0.04435
Dcorrected = +0.3199 mm

4.4 Environmental Factors

Since the purpose of the strandmeter installation is to monitor site conditions, factors that 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 strandmeters is confined to periodic checks of cable connections and maintenance of terminals. Once installed, the gauges 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. **Gauges should not be opened in the field.** For additional troubleshooting and support, contact Geokon.

Symptom: Thermistor resistance is too high:

✓ There may be 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:

✓ There may be 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 strandmeter. 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 (as shown in Figure 1) the readings will likely be unstable because the vibrating wire is out of its specified range.
✓ 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. (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 2 on the following page shows the expected resistance for the various wire combinations; Table 3 is provided to fill in the actual resistance found. Cable resistance is approximately 14.7 Ω per 1000' 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	**≅150Ω**	infinite	infinite	infinite
Black	**≅150Ω**	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 2 - Sample Resistance

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

Table 3 - Resistance Work Sheet

APPENDIX A. SPECIFICATIONS

A.1 Model 4410 Vibrating Wire Strandmeter

Range:[1]	3 mm 0.125 inches
Resolution:[2]	0.025% FSR
Accuracy:[3]	±0.1% F.S.
Linearity:	0.25% FSR
Thermal Zero Shift:	< 0.05% FSR/°C
Stability:	< 0.2%/yr (under static conditions)
Overrange:	115%
Temperature Range:	-20 to +80 °C -4 to 176 °F
Frequency Range:	1200 - 2800 Hz
Coil Resistance:	150 Ω, ±10 Ω
Cable Type:[4]	Two twisted pair (four conductor) 22 AWG Foil shield, PVC jacket, nominal OD=6.3 mm (0.250")
Length x Width	203 x 45 mm (clamp width)
Weight: (with gauge clamps)	0.5 kg. 1.1 lb.

Table 4 - Model 4410 Strandmeter Specifications

Notes:
[1] Other ranges available, consult factory.
[2] Minimum, greater resolution possible depending on readout.
[3] Accuracy established under lab conditions.
[4] Polyurethane jacket cable available.

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 7 - 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 5 - Thermistor Resistance versus Temperature