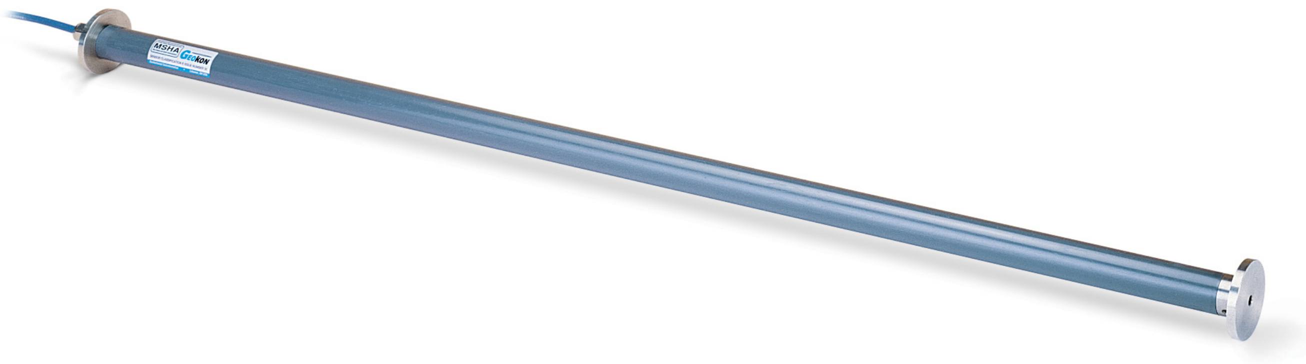
Model 4430

VW Deformation Meter

Instruction Manual



GEOKON

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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

The GEOKON Model 4430 Vibrating Wire Deformation Meter is designed to measure axial deformations in boreholes in rock, concrete or soil. The units can be installed in series providing incremental deformation measurements over any length. Base lengths of the sensor can vary from a minimum of 1 m (3.28') to over 25 m (82').

The basic sensing element is a vibrating wire strain gauge in series with a precision music wire spring that is coupled to a movable shaft. As the shaft moves in or out of the sensor body, the tension changes in the spring as well as the vibrating wire element. This change in tension is directly proportional to the amount of extension and, through calibration, a calibration factor that relates the frequency of vibration to the amount of extension is determined. The unit is stress relieved after manufacture providing for excellent stability over long periods of time.

The sensor is attached to a flange at one end and by a connecting rod of some length to a flange at the other end. The sensor and the rod are covered by a plastic (PVC) tube which holds the end flanges apart at a predetermined distance (gauge length) and insures that the rod is free to move. As the flanges move apart, the movement is conveyed by the connecting rod to the sensor and measured by the readout system. Different combinations of gauge length and sensor range provide for optimum sensitivity. For maximum strain resolution, a long base gauge with a short-range sensor 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.

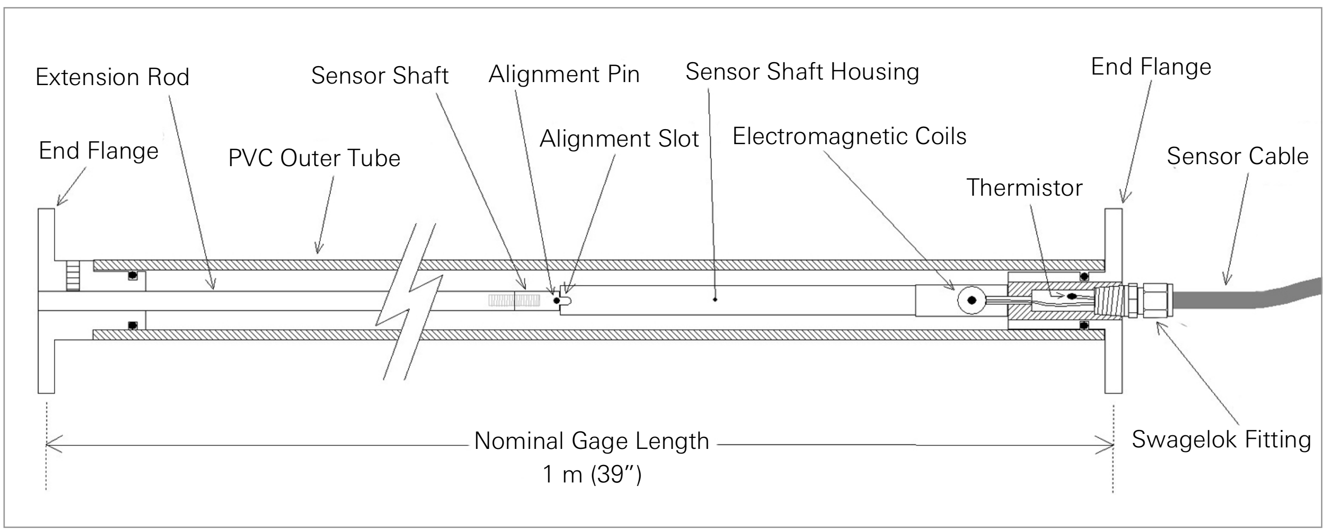

FIGURE 1: *Model 4430 Vibrating Wire Deformation Meter*

Readouts available from GEOKON, used in conjunction with the vibrating wire deformation meter, will provide the necessary voltage pulses to pluck the wire and convert the measured frequencies to display the reading.

2. PRIOR TO INSTALLATION

2.1 PRELIMINARY TESTS

GEOKON recommends that each sensor is function tested before installing in the field. To perform this preliminary check complete the following steps. For disassembled units start at Step 1, for fully assembled units start at Step 2.

1. Carefully remove the shipping spacer(s) or wire. Sensors are shipped with shipping spacer(s) installed that maintain tension to prevent damage during transportation. Installed spacers are different depending on the range of the sensor:

Important! Care should be taken to not rotate the push rod in relation to the sensor housing or to let the push rod snap back uncontrolled into the housing.

- **Ranges 12.5 mm (0.50”) through 50 mm (2"):** Sensors are secured using a shipping wire inserted into a machined hole and coiled around the shaft.
- **Ranges of 100 mm (4") or More:** Sensors are secured using stackable slotted sleeves around the shaft.

2. Connect the sensor to a readout. This could be a portable, handheld readout or the system that will be used in the final installation.
3. The sensor should have a strong, stable signal. When the end flanges of the sensor are pulled, the frequency or digits should increase. When retracted into the sensor housing, the readings should decrease. The temperature reading should match the ambient temperature.

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

4. Check electrical continuity using an ohmmeter. Resistance between the sensor leads (usually red and black) should be approximately 180 ohms. Remember to add cable resistance, which is approximately 48.5Ω per km (14.7Ω per 1000 feet) of 22 AWG stranded copper leads at 20 °C. Multiply this factor by two to account for both directions. Resistance between thermistor leads (usually green and white) will vary based on temperature (see Appendix B). Resistance between any conductor and the shield should exceed two megaohms.

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

3. INSTALLATION

3.1 SENSOR ASSEMBLY DETAIL

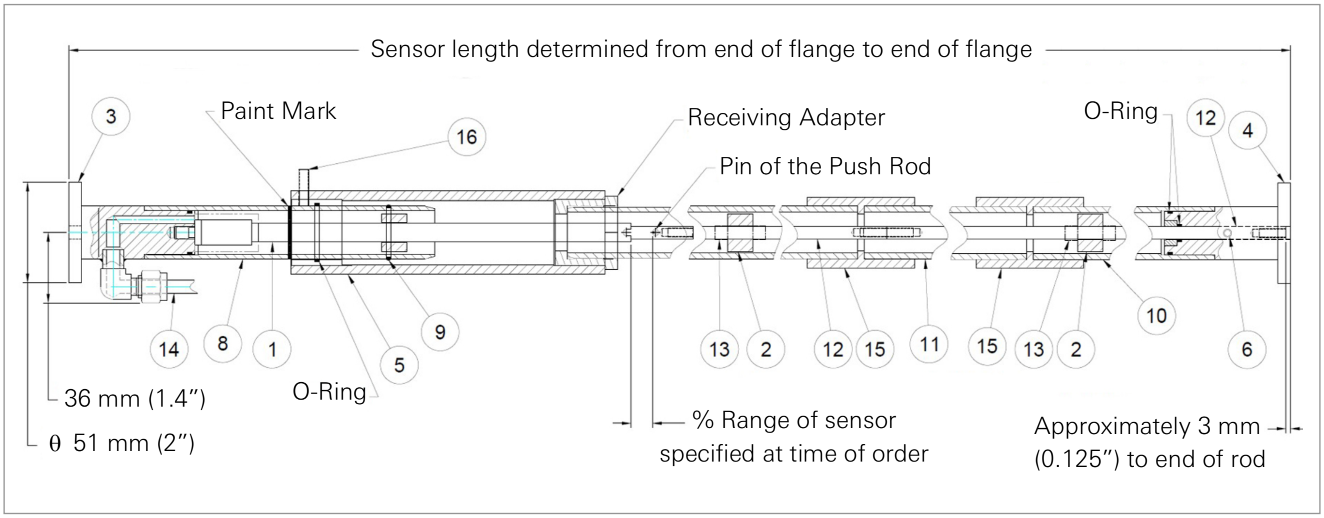

FIGURE 2: *Sensor Assembly Detail*

Item #	Description
16	Nylon Set Screw #10-32 x 3/4” LG.
15	3/4” SCH. 80 SOC x SOC Coupling
14	Signal Cable
13	Electrical Tape
12	Connecting Rod
11	STD. Pipe
10	ShafT End Flange To Coupling Tube
9	Internal Stop to Prevent Excessive Over Range
8	Flange to Slip Joint Tube
7	O-Ring Bullet (Shown Detached, Figure 3)
6	Set Screw #8-32 x 1/4 LG. (Oval Point)
5	Single Sided Slip Joint
4	Shaft End Flange w/Holes
3	Cable Flange with Elbow
2	Spacer
1	Vibrating Wire Transducer

TABLE 1: *Sensor Assembly Detail*

3.2 SENSOR ASSEMBLY

Item numbers referenced in the following steps are detailed in Section 3.1. Complete the following Step 1 through 8 for units shipped disassembled. For units shipped fully assembled skip to Step 7.

Note: Some steps may not be required depending on individual configuration.

1. Loosen the nylon set screws (Item 16) and then fully collapse the single sided slip joint (Item 5) toward the cable flange (Item 3) until it engages the internal.
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 and damage to the sensor.

3. Spacers (Item 2) should be installed along the connecting rod at approximately 0.75 m (30”) 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).
4. PVC cement (not supplied) a length of 19 mm (3/4") standard pipe (Item 11) into the receiving adapter of the single sided slip joint (Item 5).

Note: Depending on the sensor length, there may not be a standard pipe. In this case, the flange to coupling tube (item 10) may be coupled directly to the single sided slip joint.

5. For longer sensor lengths, couplings (Item 15) and additional standard pipes are provided. Use PVC cement to affix a coupling to the tubes provided. Continue to add couplings, tubes, spacers, and connecting rod until there is only the shaft end flange (Item 4) to connect.
6. 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.

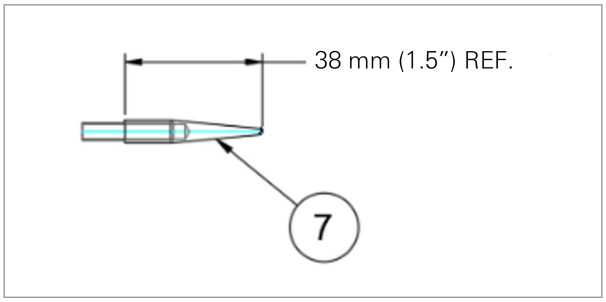

FIGURE 3: *O-Ring Bullet*

7. Extend the shaft end flange away from the cable flange until the end of the final connecting rod is about 3 mm (1/8”) below the surface of the shaft end flange. Tighten the set screws (Item 6) in the shaft end flange into the connecting rod to lock it in place.
8. Continue pulling the shaft end flange away from the cable flange until the paint mark on the flange to slip joint tube (Item 8) is aligned with the single sided slip joint.
9. Gently tighten the nylon set screws to hold the sensor at this position.
10. The gauge length and percent range of the sensor specified at the time of order should now be established. Some adjustments can still be made by manipulating the position of the single sided slip joint on the slip joint tube or by altering the position of the final connecting rod in relation to the set screws holding it in place.
11. Install the assembly. Take baseline zero readings for comparison.

Note: If the sensor has been installed with the flanges attached to fixed anchor points, loosen the nylon set screws after the flanges are secured.

3.3 SENSOR INSTALLATION

3.3.1 INSTALLATION IN BOREHOLES

The primary use of the Model 4430 is for the measurement of axial strains or deformations in boreholes. The most common method of installation is by grouting. Horizontal holes should be inclined slightly downward to make for easy grouting and to avoid air pockets. Vertical up holes require special grouting apparatus and snap ring or hydraulic anchors on the sensor to hold it in place while grouting the hole.

Horizontal and vertical down holes are instrumented as follows:

Drill the borehole at least 0.5 meters (1.6′) beyond the location of the deepest flange. The borehole must be a minimum of 60 mm (2.25") in diameter. Fill the hole with grout mixture of one-part Portland cement to one to two parts water by volume. An expansive mix is helpful particularly in horizontal holes. Lower or push the sensor(s) down the hole to the proper location as noted by a mark on the cable. If more than one sensor is to be placed in a hole, be sure to maintain the position of the lower sensor while installing shallower ones.

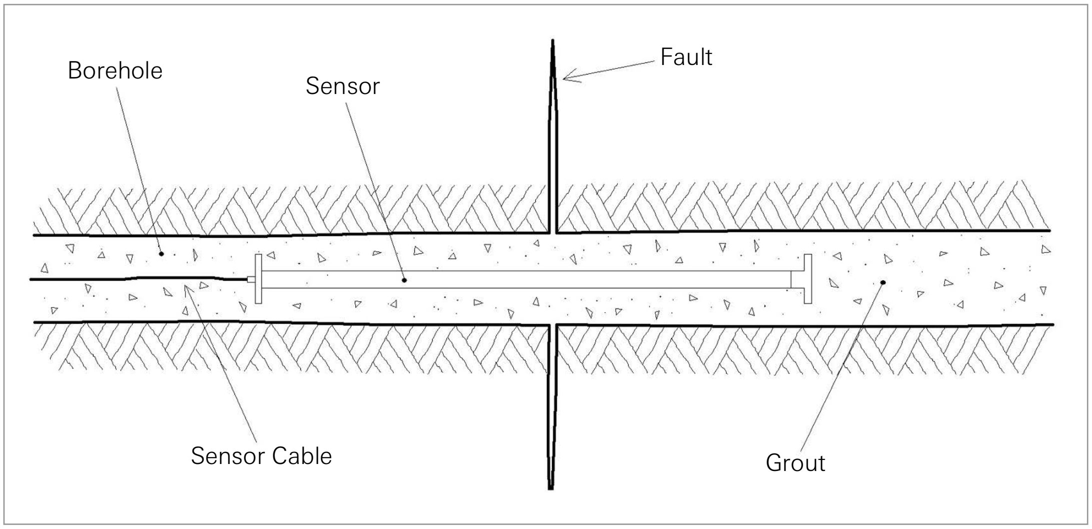

FIGURE 4: *Borehole Installation*

For situations such as soft ground or when the hole is cased, and casing must be withdrawn, it may be advisable to use a sensor with a hydraulic anchor for permanent positioning. This should be discussed with the application engineers at the factory.

3.3.2 INSTALLATION IN MASS CONCRETE

The Model 4430 can be placed directly into concrete or prewired into the rebar cage or network prior to concrete placement. Tie wires should be connected to the tube rather than the end blocks and should be perpendicular to the tube and not excessively tight to allow for shifting during placement of the concrete. The unit has a compressive modulus of approximately 200,000 psi and should follow the concrete at very early stages of curing.

3.4 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.

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

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

3.5 ELECTRICAL NOISE

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

3.6 LIGHTNING PROTECTION

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

FIGURE 5: *Model 4999-12L/LE*

Model 4999-12L/LE Manual

The module features replaceable surge protection circuitry in the event that it is damaged by a lightning strike. The Module is installed between a sensor and the datalogger or terminal box it is connected to. Consult GEOKON and the Model 4999-12L/LE Instruction Manual for additional information.

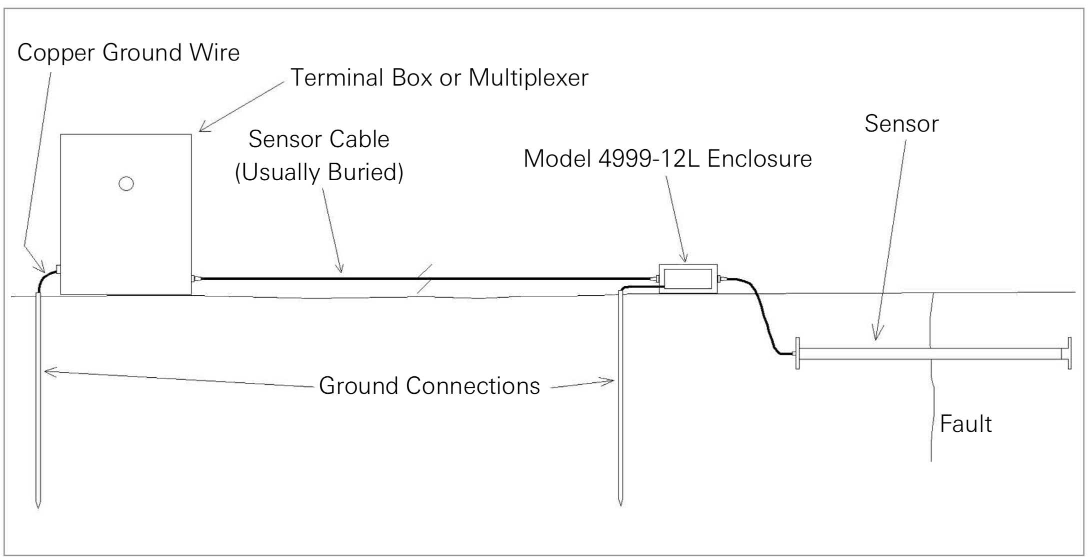

FIGURE 6: *Lightning Protection Scheme*

4. TAKING READINGS

4.1 COMPATIBLE READOUTS AND DATALOGGERS

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

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

Readouts

DIGITAL READOUTS:

- **GK-404**

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

- **GK-406**

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

Dataloggers

DATALOGGERS:

- **8600 Series**

  The MICRO-6000 Datalogger is designed to support the reading of a large number of GEOKON instruments for various unattended data collection applications through the use of GEOKON Model 8032 Multiplexers. Weatherproof packaging allows the unit to be installed in field environments where inhospitable conditions prevail. The Nema 4X enclosure also has a provision for locking to limit access to responsible field personnel.

- **GeoNet Series**

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

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

4.2 MODEL 4999 TERMINAL BOXES

Model 4999 Manual

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

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

For further details and instruction consult the Model 4999 Instruction Manual.

4.3 MEASURING TEMPERATURES

All GEOKON vibrating wire sensors are equipped with a thermistor for reading temperature. The thermistor gives a varying resistance output as the temperature changes. The white and green leads of the sensor cable are normally connected to the internal thermistor. The GK-404 and GK-406 readouts will read the thermistor and display the temperature in degrees Celsius.

USING AN OHMMETER TO READ TEMPERATURES:

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

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

5. DATA REDUCTION

5.1 DATA CALCULATION

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

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

EQUATION 1: *Digits Calculation*

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

5.1.1 LINEAR CALCULATION

To convert digits to deformation the following equation applies:

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

EQUATION 2: *Linear Deformation Calculation*

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

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

EXAMPLE:

The initial reading (R_0) at installation of a sensor is 4200 digits. The current reading (R_1) is 6000 digits. The calibration factor (G) is 0.02350 mm/digit. The deformation change is:

$$D = 0.02350(6000 - 4200)$$

$$D = 42.3 \text{ mm}$$

Note that increasing (positive) readings indicate increasing extension.

5.1.2 POLYNOMIAL CALCULATION

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

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

EQUATION 3: *Polynomial Deformation Calculation*

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

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

$$0 = AR_0^{\,2} + BR_0 + C$$

EQUATION 4: *Calculation for Polynomial Gauge Factor "C"*

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

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

EXAMPLE:

The given polynomial gauge factors on the calibration are:

A = 6.0854E^{-08}

B = 0.02280

The initial reading (R_0) at installation of a sensor is 4200 digits. The current reading (R_1) is 6000 digits.

First, the gauge factor "C" must be calculated:

$$0 = AR_0^{\,2} + BR_0 + C$$

$$0 = 6.0854\times10^{-8} \times 4200^2 + 0.02280 \times 4200 + C$$

$$0 = 96.8334 + C$$

$$C = -96.8334$$

The displacement change is:

$$D = AR_1^{\,2} + BR_1 + C$$

$$D = 6.0854\times10^{-8} \times 6000^2 + 0.02280 \times 6000 + (-96.8334)$$

$$D = -42.15 \text{ mm}$$

Note that increasing (positive) readings indicate increasing extension.

5.2 OPTIONAL CALCULATIONS

5.2.1 TEMPERATURE CORRECTION

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

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

EQUATION 5: *Thermal Correction for Deformation*

Where:
K = The thermal factor that needs to be calculated (see below).

T_1 = The current temperature reading in °C.
T_0 = The initial field temperature reading in °C.
L_C = The correction for the gauge length that needs to be calculated (see below).

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

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

EQUATION 6: *Calculation for Thermal Factor “K”*

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

Table 2 gives the multiplier and constant values used in Equation 6. The multiplier (M) and constant (B) values vary for the stroke of the sensor used.

Range	**3 mm (0.125”)**	**12 mm (0.5”)**	**25 mm (1”)**	**50 mm (2”)**	**100 mm (4”)**	**150 mm (6”)**	**300 mm (12”)**
Multiplier (M)	0.000520	0.000375	0.000369	0.000376	0.000398	0.000384	0.000424*
Constant (B)	3.567	1.08	0.572	0.328	0.0864	-0.3482	-0.6778*
(L)	184 mm (7.25”)	186.5 mm (7.35”)	205.8 mm (8.1”)	272.4 mm (10.72”)	408.8 mm (16.09”)	473.8 mm (18.66”)	939 mm (36.97”)

TABLE 2: *Thermal Coefficient Constant Values*

*Calculated

The second step in the temperature correction process is determination of the gauge length correction (L_C) based on the following equation:

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

EQUATION 7: *Calculation for Gauge Length Correction “L_C”*

Where:
L = The length, from the table above.
GL = The length of the deformation meter in millimeters or inches.
T_1 = The current temperature reading in °C.
T_0 = The initial field temperature reading in °C.

EXAMPLE:

The given multiplier and constant values for a Model 4430-1-100 mm (4”) Deformation Meter with a 762 mm (30” gauge length) are:

M = 0.000398

B = 0.0864

L = 408.8 mm

T_0 = 10 °C.

T_1 = 20 °C.

R_1 = 6000 digits

G = 0.02350 mm/digit

First, calculate the thermal coefficient (K):

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

$$K = ((6000 \times 0.000398) + 0.0864) \times 0.02350 = 0.05814$$

Second, calculate the gauge length correction (L_C):

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

$$L_C = 17.3 \times 10^{-6} \times (762 - 408.8) \times (20 - 10) = 0.06110$$

Calculate the thermal correction:

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

$$T_{Correction} = 0.05814(20 - 10) + 0.06110 = 0.6425$$

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

5.2.2 ENGINEERING UNITS CONVERSION

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

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

TABLE 3: *Engineering Units Conversion Multipliers*

5.3 ENVIRONMENTAL FACTORS

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

6. TROUBLESHOOTING

Technical Support

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

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

SYMPTOM: THERMISTOR RESISTANCE IS TOO HIGH

- ☐ Check for an open circuit. Check all connections, terminals, and plugs. If a cut is in the cable, splice according to instructions in Section 3.4.

SYMPTOM: THERMISTOR RESISTANCE IS TOO LOW

- ☐ Check for a short circuit. Check all connections, terminals, and plugs. If a short is in the cable, splice according to instructions in Section 3.4.
- ☐ Water may have penetrated the interior of the sensor. There is no remedial action.

SYMPTOM: SENSOR READING UNSTABLE

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

SYMPTOM: SENSOR FAILS TO GIVE A READING

- ☐ Check the readout with another sensor to ensure it is functioning properly.
- ☐ The sensor may have been damaged by over-ranging or shock. Inspect for damage.
- ☐ Check the resistance of the cable by connecting an ohmmeter to the sensor leads. Cable resistance is about 48.5Ω per km (14.7Ω per 1000'). If the resistance is very high or infinite, the cable is probably broken. If the resistance is very low, the sensor conductors may be shorted. If a break or a short is present, splice according to the instructions in Section 3.4. Refer to the expected resistance for the various wire combinations below.

  Vibrating Wire Sensor Lead Resistance Levels

  Red/Black Coil Resistance ≅180Ω

  Green/White 3000Ω at 25 °C

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

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

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

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

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

TABLE 4: *Sample Resistance*

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

TABLE 5: *Resistance Worksheet*

APPENDIX A. SPECIFICATIONS

A.1 MODEL 4430 SPECIFICATIONS

Range[1]	**12.5 mm (0.50"), 25 mm (1"), 50 mm (2"), 100 mm (4"), 150 mm (6"), 200 mm (8"), 300 mm (12")**
Resolution	0.025% F.S.
Gauge Length	Varies with range
Linearity	±0.5% F.S.
Accuracy	0.1% F.S. with a polynomial expression
Thermal Zero Shift	< 0.05% F.S./°C
Stability	< 0.2%/yr (under static conditions)
Overrange	115% F.S.
Temperature Range	-20 to +80 °C
Frequency Range	1400 - 3500 Hz
Coil Resistance	180 Ω, ±10Ω
Cable Type[2]	Two twisted pair (four conductor) 22 AWG Foil shield, PVC jacket, nominal OD=6.3 mm (0.250")
Length (end to end)	Varies with range
Diameter	Body: 27 mm (1") Slip Coupling: 42 mm (1.66") Flange: 51 mm (2")
Weight	Varies with range

TABLE 6: *Model 4430 Vibrating Wire Deformation Meter*

Note:

[1] Consult the factory for other lengths and ranges available.

[2] Consult the factory for alternate cable types.

A.2 THERMISTOR

See Appendix B for more information.

Thermistor Range: -80 to +150 °C

Accuracy: ±0.5 °C

APPENDIX B. THERMISTOR TEMPERATURE DERIVATION

B.1 3KΩ THERMISTOR RESISTANCE

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

Resistance to Temperature Equation:

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

EQUATION 8: *3KΩ Thermistor Resistance*

Where:
T = Temperature in °C
LnR = Natural Log of Thermistor Resistance
$A = 1.4051 \times 10^{-3}$
$B = 2.369 \times 10^{-4}$
$C = 1.019 \times 10^{-7}$
Note: Coefficients calculated over the –50 to +150 °C span.

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

TABLE 7: *3KΩ Thermistor Resistance*

GEOKON

Vibrating Wire Displacement Transducer Calibration Report

Model: 4435-1-100MM

Serial Number: 2315095

Calibration Instruction: CI-4400

Cable Length: 20 meters

Calibration Date: October 27, 2023

This calibration has been verified/validated as of 09/26/2024

Temperature: 20.3 °C

Technician: Dean O. Cowdery

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	3636	3636	3636	-0.14	-0.14	0.00	0.00
20.0	4494	4493	4494	20.01	0.01	19.98	-0.02
40.0	5350	5350	5350	40.14	0.14	40.02	0.02
60.0	6200	6200	6200	60.12	0.12	60.00	0.00
80.0	7047	7046	7047	80.01	0.01	79.98	-0.02
100.0	7891	7891	7891	99.86	-0.14	100.01	0.01

(mm) Linear Gauge Factor (G): 0.02350 **(mm/ digit)** **Regression Zero:** 3642

Polynomial Gauge Factors: **A:** 6.0854E-08 **B:** 0.02280 **C:** ______

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

(inches) Linear Gauge Factor (G): 0.0009253 **(inches/digit)**

Polynomial Gauge Factors: **A:** 2.3958E-09 **B:** 0.0008977 **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.

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FIGURE 7: *Typical Calibration Report*

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