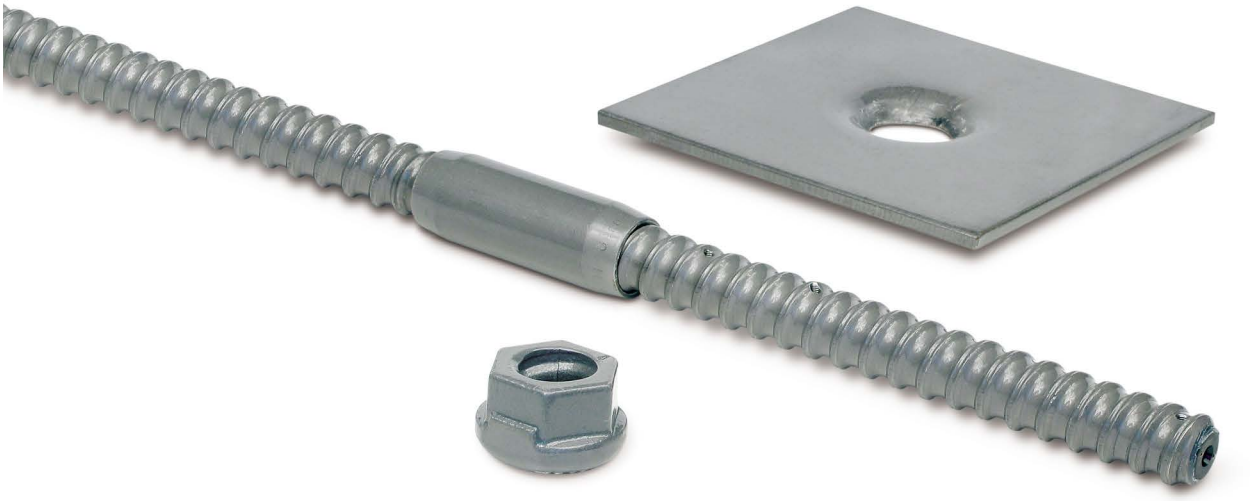
Model 4910

Vibrating Wire

Instrumented Rockbolt

Instruction Manual



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TABLE OF CONTENTS

1. INTRODUCTION 1

2. INSTALLATION 3

2.1 PRELIMINARY TESTS 3

2.2 SENSOR INSTALLATION 3

3. TAKING READINGS 4

3.1 COMPATIBLE READOUTS AND DATA LOGGERS 4

3.2 MEASURING TEMPERATURES 4

4. DATA REDUCTION 5

4.1 DATA CALCULATION 5

4.1.1 LINEAR CALCULATION 5

4.2 OPTIONAL CALCULATIONS 5

4.2.1 ENGINEERING UNITS CONVERSION 5

4.2.2 TEMPERATURE CORRECTION 6

4.3 ENVIRONMENTAL FACTORS 6

5. TROUBLESHOOTING 7

APPENDIX A. SPECIFICATIONS 8

A.1 MODEL 4910 SPECIFICATIONS 8

A.2 THERMISTOR 8

A.3 PARTS LIST 8

APPENDIX B. THERMISTOR TEMPERATURE DERIVATION 9

B.1 3KΩ THERMISTOR RESISTANCE 9

APPENDIX C. TYPICAL CALIBRATION REPORT 10

1. INTRODUCTION

The GEOKON Model 4910 Instrumented Rockbolt is made by inserting a vibrating wire strain gauge inside a short length of standard threaded rockbolt or rebar. This short length is then connected to a longer length of the same bolt material by means of a coupler. The full rockbolt assembly is then installed in the normal manner, making sure that the strain gauged portion of the bolt remains located in the loaded section of the bolt.

The Instrumented Rockbolt is frequently used:

- To confirm the load as determined by the torque applied to the rockbolt nut, or to the hydraulic pressure exerted by a jack, during installation
- To provide a permanent means of monitoring the load throughout the life of the rockbolt.

The instrumented rockbolt is read by means of a hand-held Model 4910-1 Readout Probe that is used to contact an electrode in the end of the bolt. The probe is shown in Figure 1. The probe is connected to a readout box and then the tip of the probe is pushed against the electrode recessed in the end of the rockbolt. This method of readout eliminates the need for cables and connectors, which could be damaged during or after installation.

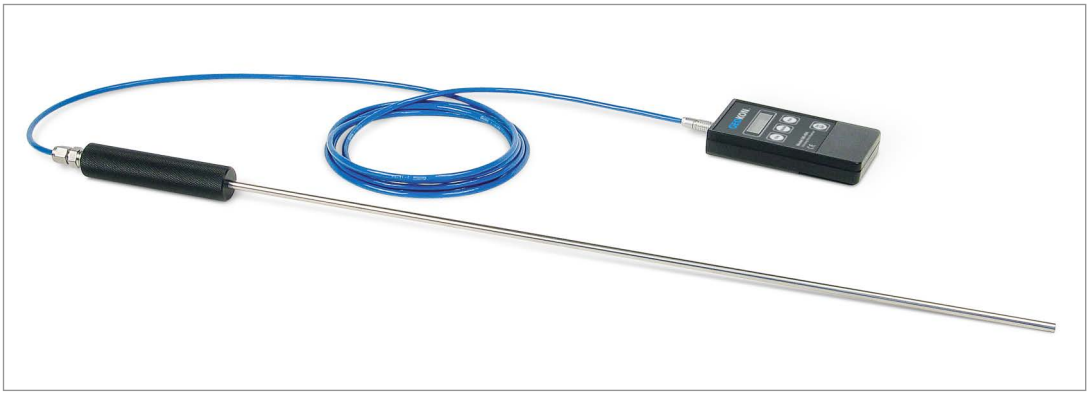


FIGURE 1: *The Model 4910 Readout Probe used with the GK-404 Readout*

A typical installation is shown in Figure 2.

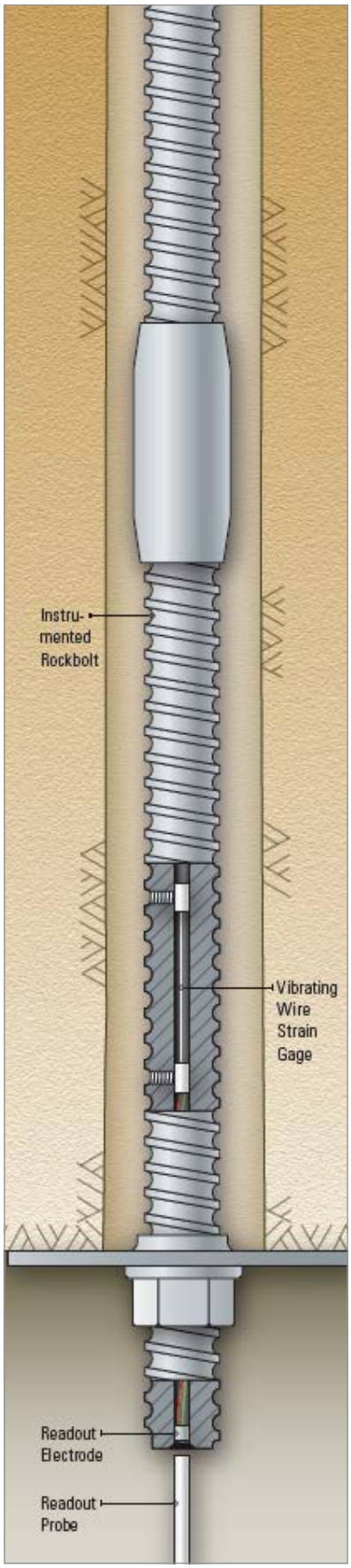


FIGURE 2: *Model 4910 Instrumented Rockbolt Typical Installation*

2. 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:

1. Connect the sensor to a readout. This could be a portable, handheld readout or the system that will be used in the final installation.
2. Take a no-load reading. This reading, when compared with the data supplied on the calibration report, will show if the sensor is functioning properly. The two readings should agree within about ±50 digits.

Important! The most important reading is the no-load reading; it is the base reading to which all subsequent readings will be compared. Note that each instrumented rockbolt has a different no-load reading, which is not zero.

Should any of these preliminary tests fail, see Section 5 for troubleshooting tips.

2.2 SENSOR INSTALLATION

Connect the instrumented section to the rest of the rockbolt using the coupler provided make sure that the electrode end points out of the end of the bolt. Tighten the connector then install the bolt in the normal manner being sure to position the nut and bearing plate so that the strain gauge inside the instrumented rockbolt is positioned inside the borehole so that it will experience the full load in the bolt. Do not run the nut up so far that it lies over the strain gauge.

3. TAKING READINGS

3.1 COMPATIBLE READOUTS AND DATA LOGGERS

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

DIGITAL READOUTS:

- **GK-404**

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

- **GK-406**

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

DATA LOGGERS:

- **GeoNet Series**

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

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

- **8600 Series**

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

3.2 MEASURING TEMPERATURES

The Model 4910-1 Readout Probe is 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.

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

4. DATA REDUCTION

4.1 DATA CALCULATION

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

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

EQUATION 1: *Digits Calculation*

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

4.1.1 LINEAR CALCULATION

To convert digits to load the following equation applies:

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

EQUATION 2: *Linear Load Calculation*

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

R_1 = The current reading in digits.
R_0 = The no-load field zero reading in digits.

EXAMPLE:

The no-load reading (R_0) before installation of a sensor is 7138 digits. The current reading (R_1) is 8500 digits. The calibration factor (G) is 8.092 lbs/digit. The load change is:

$$D = (8500 - 7138) \times 8.092$$

$$D = 11020 \text{ lbs}$$

Note that increasing (positive) readings indicate increasing load.

Note: The equations assume a linear relationship between load and gauge readings **over the full load range**, and the linear coefficient is obtained using regression techniques. **Note that when using the Calibration Factor obtained from the regression formula it is better to use the regression zero. This may introduce substantial errors at very low loads.** A measure of the amount of non-linearity is shown on the calibration report in the column entitled "Linearity".

4.2 OPTIONAL CALCULATIONS

4.2.1 ENGINEERING UNITS CONVERSION

To convert to a different engineering unit, take the result from data calculation and multiply it by the appropriate conversion multiplier from Table 1.

		CONVERT FROM				
		Pounds	**Kilograms**	**Kips**	**Tons**	**Metric Tonnes**
CONVERT TO	**Pounds**	1	2.205	1000	2000	2205
	Kilograms	0.4535	1	453.5	907	1000
	Kips	0.001	0.002205	1	2	2.205
	Tons	0.0005	0.0011025	2	1	1.1025
	Metric Tonnes	0.0004535	0.001	0.4535	0.907	1

TABLE 1: *Engineering Units Conversion Multipliers*

4.2.2 TEMPERATURE CORRECTION

Since the vibrating wire has the same temperature coefficient as the steel rockbolt, no temperature correction is required.

4.3 ENVIRONMENTAL FACTORS

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

5. TROUBLESHOOTING

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

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

SYMPTOM: SENSOR READING UNSTABLE

- ☐ Is the readout box position set correctly? If using a data logger to record readings automatically, are the swept frequency excitation settings correct?
- ☐ Check the readout with another sensor to ensure it is functioning properly.

SYMPTOM: SENSOR FAILS TO GIVE A READING

- ☐ Is the electrode covered with dirt? Clean the electrode with a swab attached to the readout probe. Use electro contact cleaner or similar product.
- ☐ 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.

APPENDIX A. SPECIFICATIONS

A.1 MODEL 4910 SPECIFICATIONS

Range	2500 με (equivalent to 27,215 kg in a 25 mm diameter bolt)
Resolution	0.5 με (equivalent to 5 kg in a 25 mm diameter bolt)
Linearity	±0.5% F.S.
Accuracy[1]	±0.25% F.S.
Repeatability	0.1% F.S.
Overrange	150% F.S.
Temperature Range[2]	-20 to +80 °C
Temperature Effect	Zero
Frequency Output Range	1400 - 3500 Hz
Bolt Size	25 mm, or #8 rebar, and larger
Rockbolt Length[3]	1 m (standard)

TABLE 2: *Model 4910 Vibrating Wire Instrumented Rockbolt Specifications*

Note:

[1] Accuracy established under laboratory conditions.

[2] Other ranges available on request.

[3] Other lengths sufficient to reach rockbolts located in the roofs of tunnels, etc., are available on request.

A.2 THERMISTOR

See Appendix B for more information.

Thermistor Range: -80 to +150 °C

Accuracy: ±0.5 °C

A.3 PARTS LIST

Part Number	Description
4910-1	Reading probe, 6' probe with 5' cable.

TABLE 3: *Model 4910 Parts List*

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 3: *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 4: *3KΩ Thermistor Resistance*

APPENDIX C. TYPICAL CALIBRATION REPORT

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

Instrumented Rockbolt Calibration Report

Model Number : 4910-8

Serial Number: 05-13400

Prestress: 30,000 psi

Temperature: 23.3 °C

Date of Calibration: August 24, 2005

Cal. Std. Control Numbers: 85888-1, 398

Factory Zero Reading: 7131

Regression Zero: 7138

Technician: K.L.Bellavance

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
400	7193	7196	7195		
6,000	7868	7873	7871	676	-0.27
12,000	8610	8619	8615	744	-0.18
18,000	9364	9371	9368	753	0.22
24,000	10100	10106	10103	736	0.02
400	7197				

Gage Factor: 8.092 lbs/ digit (GK-404 Pos."B")

Calculated Load = Gage Factor(Current Reading - Zero Reading)

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

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 3: *Typical Calibration Report*

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