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Instruction Manual

Model 4910

Instrumented Rockbolt

(Doc Rev B, 05/02/19)

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 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 out by means of a hand-held 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 installation or later.

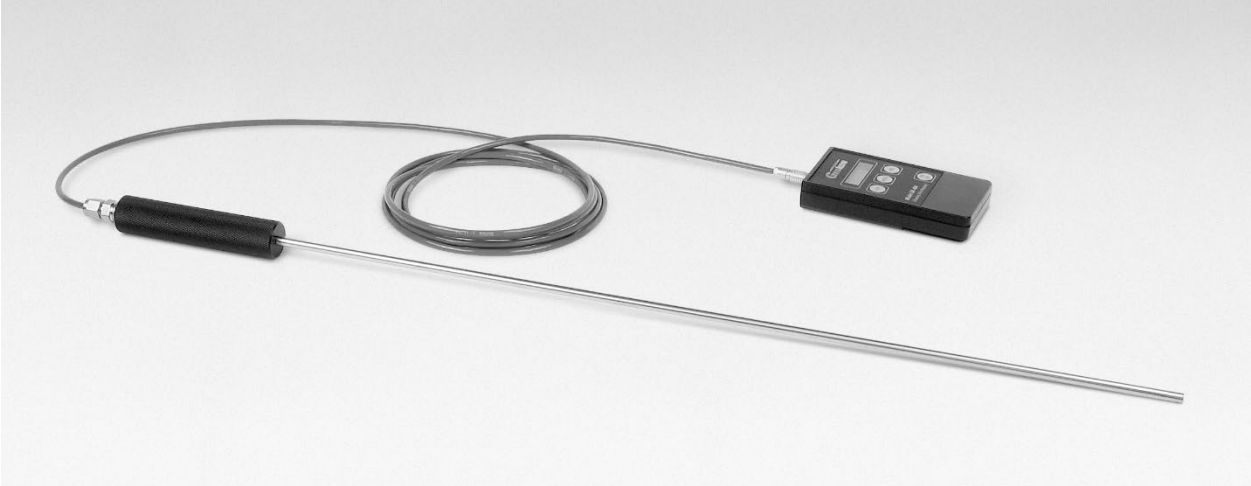

Figure 1 - The 4910 Readout Probe used with the GK-404 Readout.

Figure 2 on the following page shows a typical installation.

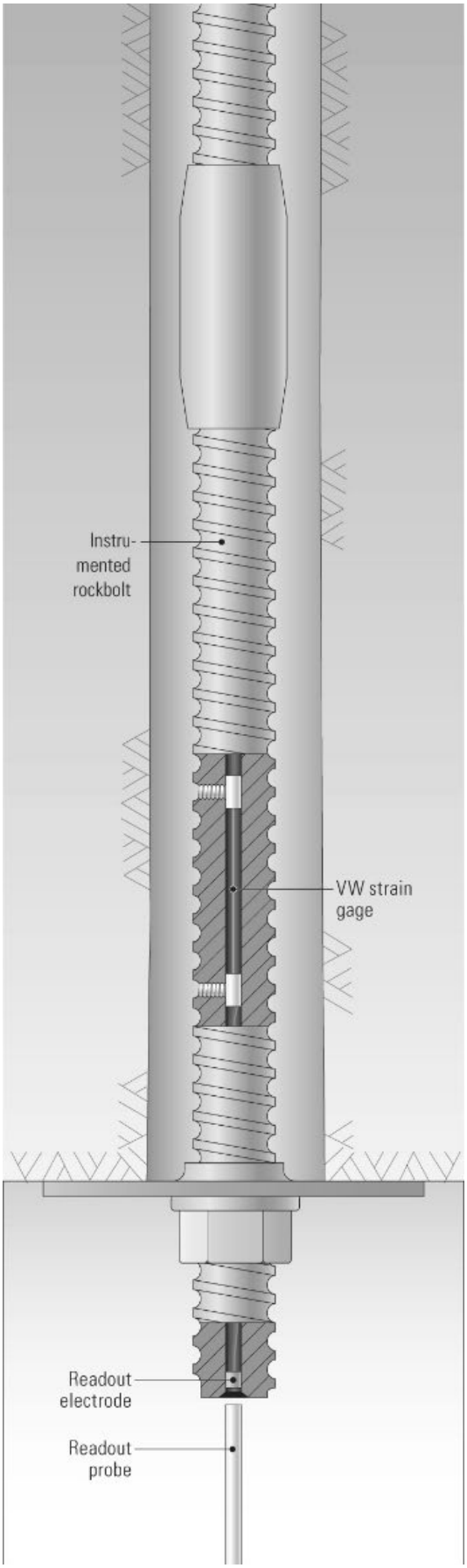

Figure 2 - Model 4910 Installation

2. INSTALLATION

2.1 Preliminary Tests

Before installing the Instrumented Rockbolt, it should be checked by connecting it to the readout box and taking a no-load reading. This reading, when compared with that given in the calibration data provided with the load cell, will show if the sensor is functioning properly. The two readings should agree within about ±50 digits. See Section 3 for readout instructions.

Before installing the Instrumented Rockbolt be sure to take the no-load reading. This reading is very important since it is the reading that will be subtracted from all subsequent readings to calculate the load. Note that each Instrumented Rockbolt has a different no-load reading, which is not zero. See Section 3 for operation of the Readout Boxes.

2.2 Instrumented Rockbolt 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 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).

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 3). Insert the Lemo connector into the GK-404 until it locks into place.

Figure 3 - 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 see 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

Connecting sensors with 10-pin connectors:
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).

3.2.2 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 4 shows a typical vibrating wire output in digits. If no reading displays or the reading is unstable, see Section 5 for troubleshooting suggestions. For further information, consult the GK-405 Instruction Manual.

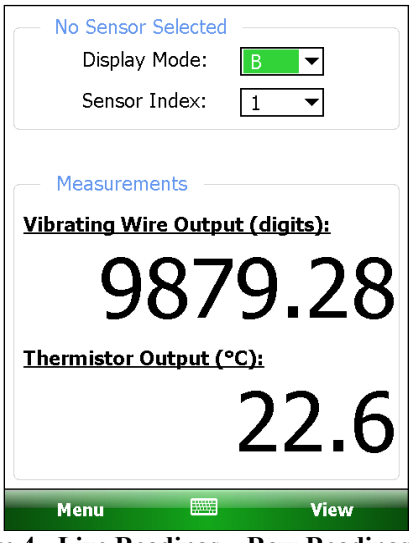

Figure 4 - Live Readings – Raw Readings

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

Connecting sensors with 10-pin connectors:
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) 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 turn off automatically after approximately two minutes to conserve power.

4. DATA REDUCTION

4.1 Load Calculation

The basic units utilized by Geokon for measurement and reduction of data from Instrumented Rockbolts 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 the digits readings to load, the gauge readings for each cell must be multiplied by the gauge factor supplied with the Instrumented Rockbolt.

$$L = (R_1 - R_0) \times G \times K$$

Equation 2 - Load Calculation Using Linear Regression

Where;
L is the load in lbs. or kg. etc.
R_0 is the **regression** no-load reading in digits s supplied on the calibration report. (A sample calibration report is given in Appendix B.)
R_1 is the current reading in digits
G is the gauge factor as supplied on the calibration report.
K is the conversion factor (optional) as listed in Table 1.

From→ To↓	Lbs.	Kg.	Kips	Tons	Metric Tonnes
Lbs.	1	2.205	1000	2000	2205
Kg.	0.4535	1	453.5	907.0	1000
Kips	0.001	0.002205	1	2.0	2.205
Tons	0.0005	0.0011025	2.0	1	1.1025
Metric Tonnes	0.0004535	0.001	0.4535	0.907	1

Table 1 - Engineering Units Conversion Multipliers

For example:

If;
$R_0 = 7138$
$R_1 = 8500$
G = 8.092 .lbs per digit

Then;

$L = (8500 - 7138) \times 8.092 = 11{,}020$ lbs.

Note that 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 Temperature Correction Factor

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

5. TROUBLESHOOTING

Problems with the instrumented rockbolt are usually associated with dirty electrodes.

Symptom: Instrumented Rockbolt Readings are Unstable:

✓ Is the readout box position set correctly? (Use Channel B.)
✓ Does the readout work with another instrumented rockbolt? If not, the readout may have a low battery or be malfunctioning.

Symptom: Instrumented Rockbolt Fails to Read:

✓ Is the electrode covered with dirt? Clean the electrode with a swab attached to the readout probe. Use electro contact cleaner or similar product.
✓ Does the readout or datalogger work with another Instrumented rockbolt? If not, the readout or datalogger may be malfunctioning.

APPENDIX A. SPECIFICATIONS

A.1 Specifications

Available Ranges:	2500 microstrain (equivalent to 27,000 kg in a 25 mm diameter bolt)
Accuracy:	±0.25% FS
Linearity:	0.5% FSR
Resolution:	0.5 microstrain (equivalent to 5 kg in a 25 mm dia. bolt)
Repeatability:	0.1% FSR
Temperature Effect:	zero
Temperature Range:	–40 to +80° C -40 to 110° F
Frequency Output Range	1400-3000 Hz
Over-range:	150%
Bolt Size	25 mm or #8 rebar and larger.
Length	300 mm (standard) (other lengths are optional)

Table 2 - Model 4910 Instrumented Rockbolt Specifications.

APPENDIX B. SAMPLE 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: KLBellavance

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.

Figure 5 - Typical Model 4910 Calibration Report