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Instruction Manual

Model 4910

Instrumented Rockbolt

(Doc Rev A, 6/13)

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1. INTRODUCTION

1.1. Theory of Operation

The Geokon Model 4910 Instrumented Rockbolt is made by inseting a vibrating wire strain gage inside a short length of standard threaded rockbolt or rebar. This short length is then connected to a longer length of 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 gaged 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 instalation
- ⇨ To provide a permanent means of monitoring the load throughout the life of the rockbolt.

Figure 1 shows a typical installation.

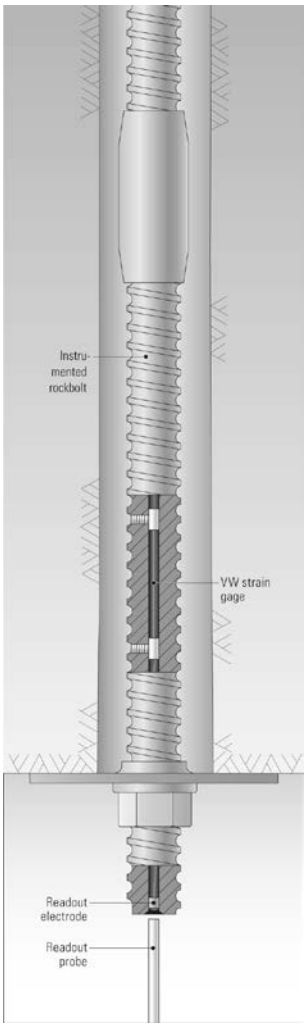

Figure 1 Model 4910 Installation

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 2. 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 connectorswhich could be damaged during installation or later.

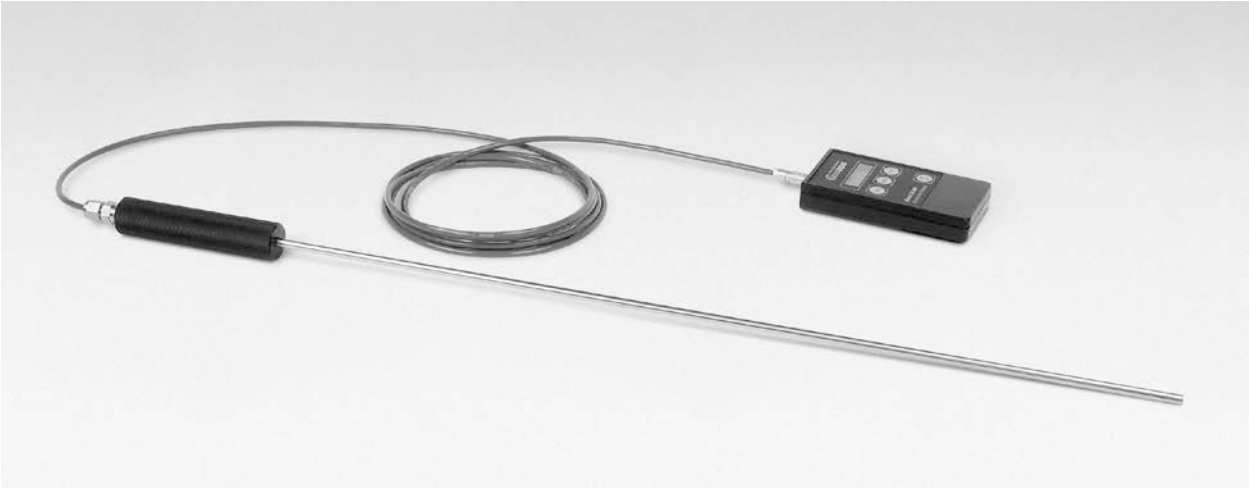

Figure 2 The 4910 Readout Probe used with the GK404 Readout.

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.

2.2. Instrumented Rockbolt Installation

2.2.1 Initial No-Load Reading

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 in order 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.

2.2.2 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 blt in the normal manner being sure to position the nut and bearing plate so that the strain gage 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 gage.

3. TAKING READINGS

3.1. Operation of the GK-403 Readout Box

3.3.1. Using the Flying Leads

Each sensor is read in turn by plugging the flying lead connector from the Readout Probe into the readout box at the "TRANSDUCER" port. Switch the GK-403 "DISPLAY" selector switch to "B". The sensor output is displayed in digits. Read each channel in turn and record in a field book and/or by depressing the "STORE" button. When using the "STORE" button it will be necessary to use the joystick to set the appropriate I.D. Marker on the display screen before the "STORE" button is depressed to distinguish individual gages (and load cells) from each other.

The GK-403 will turn itself off after about 2 minutes.

- Readings on all channels can be stored in the GK-403 memory at any time by depressing the "SELECT/STORE" button. To distinguish sets of readings taken at different times use the ROW number, by advancing the row number with every set of readings. Any sets of readings at any particular time can be accessed and inspected by scrolling through the ROW numbers. Note that storing data on any ROW number will erase and write over any data already stored on that ROW.

- A useful feature of the GK-403 is its ability to display the previous readings taken on any channel. On the main screen the reading is at the bottom of the screen. Thus any sudden changes of load from one time to the next are immediately apparent.

3.2 Operation of the GK-404 Readout Box

The GK404 is a palm sized readout box which displays the vibrating wire value and the temperature in degrees centigrade.

In the case of the Instrumented Rockbolt the Readout Probe is plugged directly into the connector on the GK404

(The GK-404 Vibrating Wire Readout arrives with a patch cord for connecting to the vibrating wire gages. One end will consist of a 5-pin plug for connecting to the respective socket on the bottom of the GK-404 enclosure. The other end will consist of 5 leads terminated with alligator clips. Note the colors of the alligator clips are red, black, green, white and blue. The colors represent the positive vibrating wire gage lead (red), negative vibrating wire gage lead (black), positive thermistor lead (green), negative thermistor lead (white) and transducer cable drain wire (blue). The clips should be connected to their respectively colored leads from the vibrating wire gage cable).

Use the **POS** (Position) button to select position **B** and the MODE button to select **Dg** (digits).

Other functions can be selected as described in the GK404 Manual.

The GK-404 will continue to take measurements and display the readings until the OFF button is pushed, or if enabled, when the automatic Power-Off timer shuts the GK-404 off.

The GK-404 continuously monitors the status of the (2) 1.5V AA cells, and when their combined voltage drops to 2V, the message **Batteries Low** is displayed on the screen. A fresh set of 1.5V AA batteries should be installed at this point

3.3 Operation of the 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
- the GK-405 Remote Module which is housed in a weather-proof enclosure and connects to the vibrating wire sensor by means of:

1) Flying leads with alligator type clips when the sensor cable terminates in bare wires or,
2) by means of a 10 pin connector..

The two components communicate wirelessly using Bluetooth®, a reliable digital communications protocol. The Readout Unit can operate from the cradle of the Remote Module (see Figure 3) or, if more convenient, can be removed and operated up to 20 meters from the Remote Module

Figure 3 GK-405 Readout Unit

For further details consult the GK-405 Instruction Manual

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;

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

Equation 1 - Digits Calculation

To convert the digits readings to load, the gage readings for each cell must be multiplied by the gage factor supplied with the Instrumented Rockbolt.

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

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 (See calibration sheet).
R_1 is the current reading in digits
G is the gage factor as supplied on the Calibration Sheet (Figure 4).
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, a Model 4910 has a regression no-load reading (R_0) of 7138 (see Figure 4) and a current reading (R_1) of 8500. The Calibration Factor is 8.092.lbs per digit.

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

Note that the equations assume a linear relationship between load and gage 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 Sheet in the column entitled "Linearity". (See Figure 3).

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 effect 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.

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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 4 - Typical Model 4910 Calibration Sheet

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 simlar 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. Model 4910 Instrumented Rockbolt Specifications

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

Table A-1 Model 4910 Instrumented Rockbolt Specifications.