Model 3000

Resistance Load Cell

Instruction Manual



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1. INTRODUCTION

1.1 THEORY OF OPERATION

The GEOKON Model 3000 Resistance Load Cells are of an annular design primarily for use on tiebacks and rockbolts. They may also be used during pile load tests and for monitoring loads in cross-lot struts and tunnel supports, etc. In practically all cases, the load cells are used in conjunction with a hydraulic jack, which applies the load, and with bearing plates positioned on either side of the load cell.

GEOKON Model 3000 Resistance Load Cells are frequently used for the following:

- To provide a permanent means of monitoring the load throughout the life of the tieback, rockbolt, strut or support, etc.
- To provide an electronic output for automatic data gathering.
- As a check on the load as determined by the hydraulic pressure applied to the jack during proof testing on tiebacks, rockbolts, etc. **For this purpose, the user should be aware that the agreement cannot be guaranteed better than ±20% because of the many variables.**

Load cells are positioned so that the tensile load in the tieback or rockbolt produces a compressive load in the load cell. This is done by trapping the load cell between bearing plates positioned between the jack and the structure, either below the anchor plate for permanent installations or above the anchor plate for proof testing. Figure 1 and Figure 2 show the two different installations.

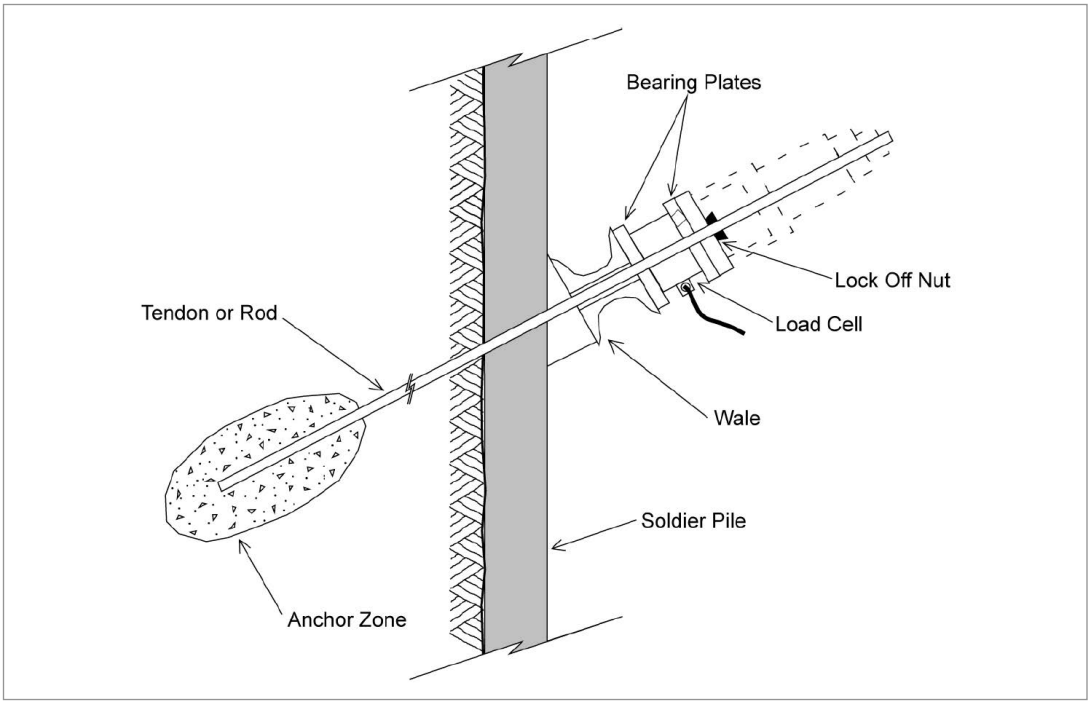


FIGURE 1: *Load Cells on Tiebacks for the Permanent Monitoring of Loads*

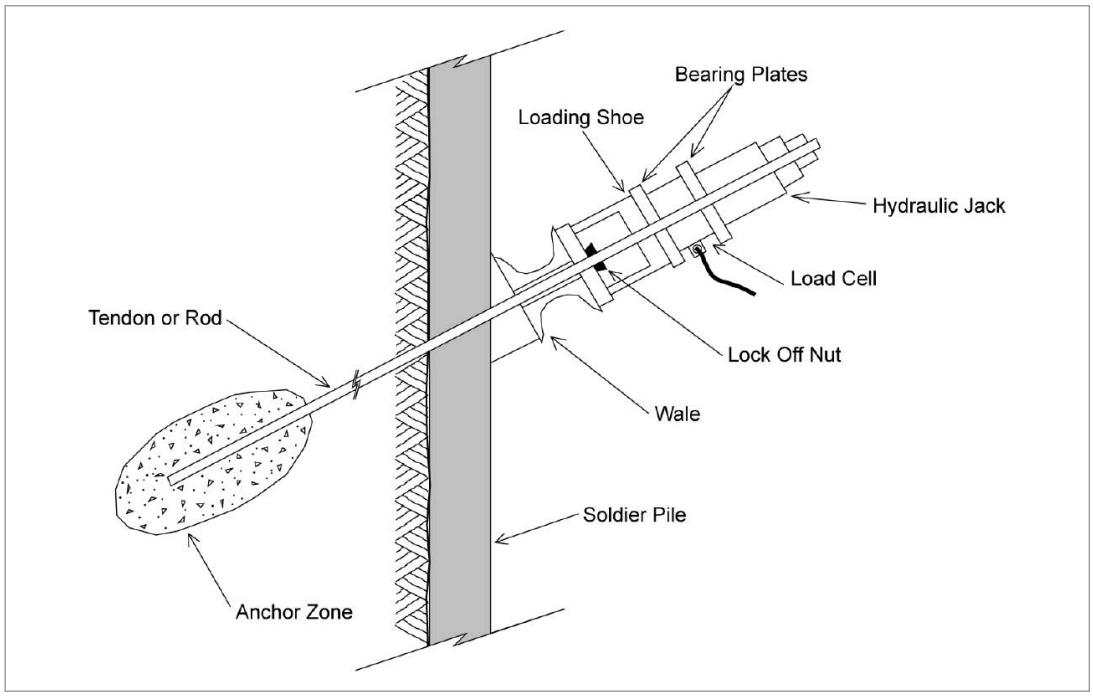


FIGURE 2: *Load Cells on Tiebacks For Proof Testing Only*

1.2 LOAD CELL DESIGN AND CONSTRUCTION

The Model 3000 Load Cell is made from an annulus of high strength steel or aluminum. Electrical resistance strain gauges are cemented around the outside of the annulus and connected in a Wheatstone Bridge circuit. Half the gauges measure vertical strains, the other half measure circumferential strain. Appendix A shows typical specifications; Appendix B illustrates typical wiring diagrams. Note that the GK-502 Readout Box uses a remote sensing technique to reduce the cable effects. This means that load cells for use with the GK-502 have a six-conductor cable (three individually shielded twisted pairs). See Appendix B for connector wiring.

An outer shell protects the gauges from damage and o-rings on either side of the gauges ensure that the load cell is fully waterproof. The cable is attached to the cell through a waterproof gland. A Kellem's grip strain relief prevents the cable from being pulled out of the cell. Cables have thick PVC jackets and can be terminated in a 10-pin connector to mate with the GK-502 Readout Box. The figure below shows a typical strain gauge load cell.

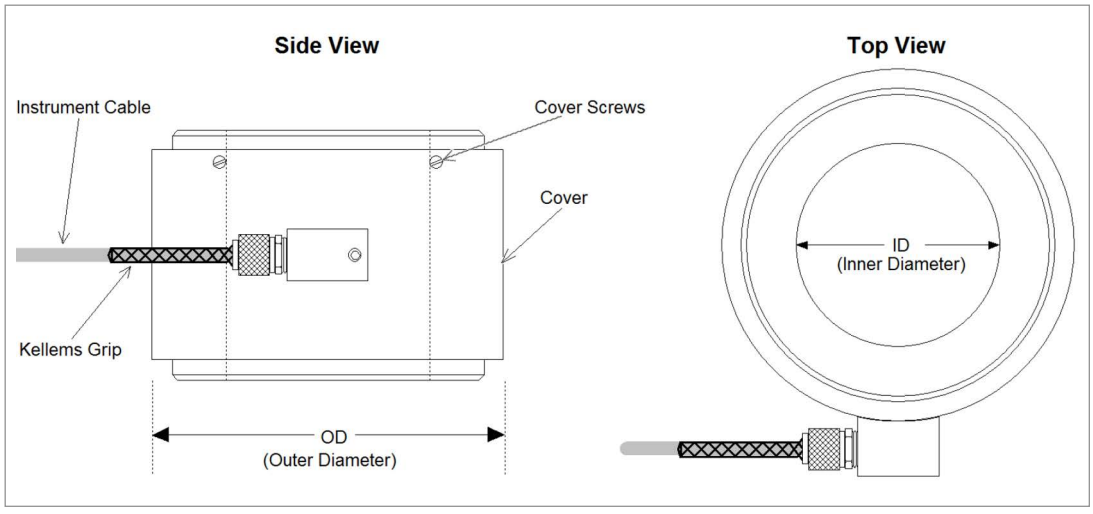


FIGURE 3: *Model 3000 Load Cell*

Additional cable protection can be obtained by either using armored cable or by placing the cable inside flex conduit. The figure below shows a typical load cell system.

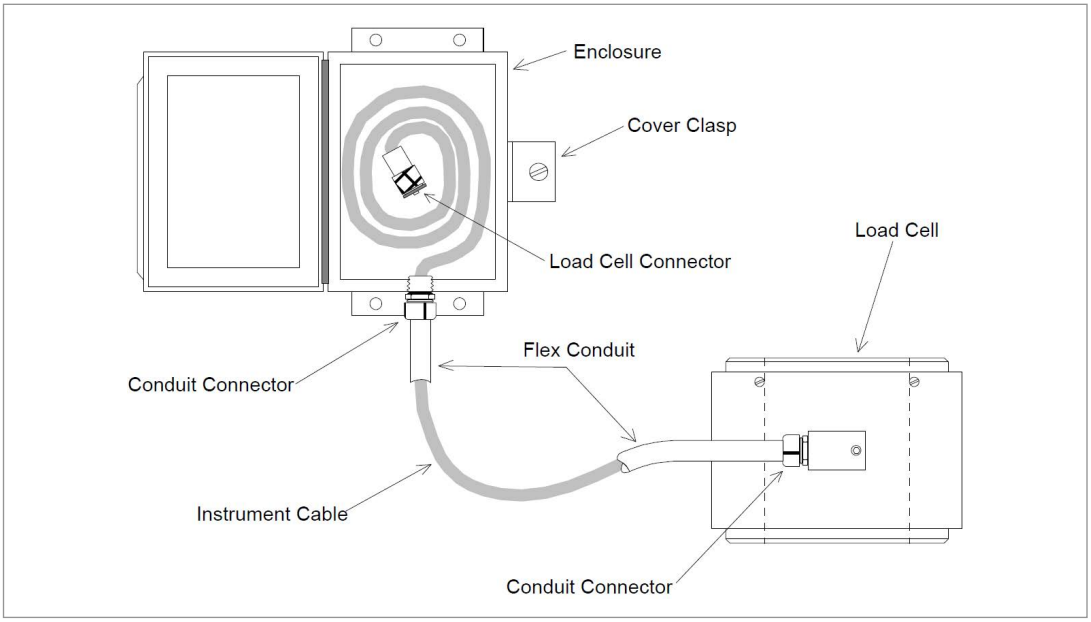


FIGURE 4: *Typical Load Cell System*

Annular load cells, because of their design, are inherently susceptible to varying conditions of end loading, unlike solid load cells, which can be designed with button shaped ends so that the load always falls in a uniform, predictable fashion. Thus, the output and calibration of an annular load cell can be affected by the factors discussed in the subsections below. Note that all of these effects can be accumulative, and can cause **the calibration to vary by as much as 20%**, unless special precautions are taken.

1.2.1 FRICTION BETWEEN THE BEARING PLATE AND LOAD CELL

Friction between the bearing plate and the load cell can radically affect the performance of a load cell. Interposing deformable plates or lubricant between the bearing plates and the load cell in the field will cause the load cell to overregister, perhaps by as much as 10%. Again, **for best results, it is important to calibrate the load cell in the laboratory under the same loading conditions as will be used in the field.**

End effects of this nature can be reduced somewhat by using tall load cells. A rough rule of thumb for good load cell design calls for a load cell height at least four times the wall thickness of the loaded annulus. On some jobs where there are space restrictions calling for a pancake style load cell, friction between bearing plates and load cell can give rise to large hysteresis effects between loading and unloading cycles.

1.2.2 WARPING OF THE BEARING PLATE AND BEARING PLATE DESIGN

Warping of the bearing plates is caused primarily by a size mismatch between the hydraulic jack and the load cell. A jack larger than the load cell tends to wrap the intervening bearing plate around the load cell, causing the center of the load cell to "hourglass" or pinch inwards causing the load cell to under-register.

Conversely, a hydraulic jack, smaller than the load cell, will try to punch the intervening bearing plate through the center of the load cell, making the center of the load cell barrel outwards causing the load cell to over-register. Both effects are exacerbated by bearing plates that are too thin. For further details on this topic, see Appendix D.

Minimum bearing plate thickness is 25 mm (1") where load cell size matches hydraulic jack size, i.e., the load bearing annulus of the load cell falls within the load bearing annulus of the hydraulic jack. For any other condition of size mismatch, the bearing plates should be at least two inches thick and even thicker where the size mismatch is extreme or the loads large.

Bearing plates should be flat and smooth. The normal rolled steel plate surface is adequate. It is not necessary to have machined or ground surfaces. Where plates are cut from larger plates, using cutting torches, the edges should be carefully cleaned to remove welding slag and solidified molten lumps.

Consideration should be given to calibrating the load cell using the same bearing plates as will be used in the field. In addition, it is possible to simulate the size of the hydraulic jack using a suitably sized metal donut between the upper platen of the testing machine and the upper bearing plate. Load cells calibrated in this way will be much more likely to agree with the hydraulic jack in the field.

1.2.3 ECCENTRIC LOADING

Eccentric loading of load cells is the rule rather than the exception. Rarely is the axis of the tieback, rockbolt, or strut at right angles to the surface on which the anchor plate or strut rests. With tiebacks using multiple tendons, it is quite common for loads in individual tendons to vary markedly, despite best efforts to avoid this happening. In addition, struts are rarely at right angles to the soldier piles they may be supporting.

These factors combine to produce conditions in which the load cell experiences loads that are higher on one side than on the other. This effect is compensated for by the individual electrical resistance strain gauges, cemented to the cell, being connected together in a full Wheatstone Bridge circuit. Thus, the higher strains on one side are balanced by lower strains on the other and the average strain is not affected. Thus, even gross amounts of load eccentricity cause only slight (< 5%) variations in the load cell output and calibration. This is certainly an attractive feature of the electrical resistance type load cell.

Eccentric loading can be minimized by using spherical bearing plates, but this is expensive and is rarely done. Spherical seats may be of some value during pile load testing where uniformity of the load on the top of the pile is highly desirable.

1.2.4 ELASTIC BEHAVIOR

It is important that a load cell behave elastically, i.e. that the no-load zero will not change with time. It is important to use only the highest quality strain gauges and adhesives. GEOKON uses transducer grade strain gauges, along with scrupulous observation of the best installation practices and adhesive post curing techniques.

GEOKON Model 3000 Load Cells are designed to keep the normal working stresses below 50% of the yield stress of the load cell material. Wherever possible load cells are cycled to 150% of the design load prior to calibration. As long as the load cell is never overloaded above this range, the no-load reading will not change. The normal over-range capacity of an aluminum load cell is 200% FSR and 300-400% FSR for a steel load cell before the load cell will begin to fail.

If a load cell is over-ranged and the no-load reading is shifted due to plastic yielding of the cell, then the cell should be returned to the factory for inspection and recalibration. Note, however, that while the no-load zero may shift, the calibration constant will probably not be affected.

1.2.5 TEMPERATURE EFFECTS

Temperature compensation is achieved by using strain gauges whose thermal coefficient is the same as that of the load cell material. Normally, the temperature coefficient of the load cell is insignificant. In special cases, if required, the coefficient can be measured at the factory. It should be remembered, however, that temperature changes on the loaded rockbolt, tieback, or strut can produce real changes of load and these will be recorded by the load cell.

2. INSTALLATION

2.1 PRELIMINARY TESTS

Before installing the load cell, 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 cell is functioning properly. The two readings should agree within about 50 digits (assuming that the same readout box is used for both readings).

2.2 LOAD CELL INSTALLATION

2.2.1 TRANSPORTATION

When transporting load cells, do not pull on the cable and, in particular, **do not** carry the load cell by the cable. On the larger load cells, threaded holes are provided in the ends to allow eyebolts to be attached for lifting purposes.

2.2.2 INITIAL NO-LOAD READING

Before installing the load cell, **be sure to take the no-load reading**. This reading is very important, since it will be subtracted from all subsequent readings to calculate the load. Note that each load cell has a different no-load reading that is not zero. See the Model GK-502 Instruction Manual (geokon.com/GK-502) for operation of the GK-502. See Section 3 for operation of the Vishay P3 Readout Box.

2.2.3 INSTALLATION ON TIE-BACKS AND ROCKBOLTS

Load cells should be installed between flat steel bearing plates of sufficient thickness; one inch thick where load cell and jack are about the same size, and two to three inches thick where size mismatches are greater. The normal rolled finish on the plates is good. Plates may need to be machined flat if they are warped. Make sure that the bearing plates completely cover the load-bearing surface of the load cell. Centralize the rockbolt or tieback inside the load cell.

Where the load cell I.D. is much bigger than the rockbolt or tieback, a centralizer bushing can be used. Where the anchor block of a multi-tendon tieback bears directly on the load cell, make sure that the load cell bearing surface is completely covered by the anchor block. If the load cell is not completely covered, then make sure that **the calibration was performed using the anchor block**. If the calibration was performed without the anchor block then for best results consideration should be given to recalibration with the anchor block.

Shield the cable for possible damage from blasting or traffic. Protect the end of the cable or the cable connector from dirt by either using a cap on the connector or by storing the end of the cable and/or connector inside a small box. Figure 4 shows a typical load cell system.

2.3 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.

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 employ 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 into a receptacle on a special patch cord.

2.4 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 alongside AC power lines; they will pick up the noise from the power cable, which will likely cause unstable readings. Contact the factory concerning filtering options available for use with the GEOKON data loggers and readouts.

2.5 LIGHTNING PROTECTION

Unlike other types of instrumentation available from GEOKON, load cells do not have any integral lightning protection components, such as transorbs 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.

Recommended lightning protection is as follows:

- If the instrument 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 the installation of these components.
- Lighting arrestor boards and enclosures are also available from GEOKON. These units install where the instrument cable exits the structure being monitored. The enclosure has a removable top to allow the customer to service the components or replace the board in the event that the unit is damaged by a lightning strike. A connection is made between the enclosure and earth ground to facilitate the passing of transients away from the load cell.
- Plasma surge arrestors can be epoxied into the instrument cable, close to the load cell. A ground strap then connects the surge arrestor to an earth ground, such as a grounding stake.

Consult the factory for additional information on available lightning protection.

3. TAKING READINGS

3.1 COMPATIBLE READOUTS

Devices compatible with this product are listed below. For further details and instruction consult the corresponding Manual at geokon.com/Readouts.

DIGITAL READOUTS:

- **GK-502**

  The Model GK-502 Readout Box incorporates a 12 Volt, 1.4 Ahr Sealed Lead Acid (SLA) battery, 16x2 graphic liquid crystal display (LCD) with backlight, membrane keypad, and battery charger circuit. A side mounted 10-pin military style Bendix® connector provides connection to a sensor, and a second side mounted 10-pin military style Bendix® connector provides a USB connection (COM port) for communications and battery charging.

3.2 VISHAY MICRO-MEASUREMENTS P3 READOUT BOX

3.2.1 SINGLE LOAD CELL LOAD - OUTPUT IN ENGINEERING UNITS

To read a single load cell directly in engineering units complete the following:

1. From the main screen, select **Bridge Type** and then select **Ch 1 FB v opp**.
2. From the main menu screen and select **Gauge Factor/Scaling**.
   a. Set the Units to lb, tons, or kilograms
   b. Set the Full Scale to the full scale value of the load in engineering units taken from the GEOKON calibration sheet. E.g., if the load cell has a maximum calibrated load of 750,000 lb enter 375 tons in accordance with the units previously chosen.

Note: Because the maximum allowable number here is 99999, lb units cannot be used if the full scale load is greater than 100,000 lb.

   c. Set the F.S. mV/V to the Full Scale mv/V given on the GEOKON calibration sheet. If no value is given, then the mV/V Gauge Factor canmbe calculated by dividing the Full Scale change of digits by 4000. E.g., a load cell reads -237 at no load and 4216 at the full load of 750 kips the F.S. mV/V is (4452)/4000 = 1.113 mV/V.
   d. Set the Dec. Places to the correct number in accordance with the Units and the Full Scale reading previously chosen.
3. Record the no-load zero reading, it may be needed later.
4. Go back to the main Menu screen and select **Balance**.
5. Select the Mode: Auto and press the Balance button on the faceplate.
6. Press the balance button on the face panel a second time to select auto. This will trigger the auto balance procedure, which when completed will automatically bring up the Saving Settings menu.
7. Save the settings by pressing the Record button on the faceplate.
8. The P3 readout box display should now read zero and is ready to display the load directly in the engineering units chosen.

This configuration must be erased if the P3 readout box is used in a similar manner with a second load cell. To erase the settings, do the following:

1. Go to the Main Menu.
2. Select **Options**, **Advanced**, and then **Factory Defaults**.
3. Press the Record Button on the face panel.

Note: The auto balance feature only works when the load cell is under zero load. The readout cannot be switched from one load cell to another if the load cells are under load.

For more information, see the P3 instruction manual.

3.2.2 MULTIPLE LOAD CELLS

The simplest way to read multiple load cells using the P3 readout box is to read the output in mV/V and then use the mV/V gauge factor calculated as shown in Section 4.2. The P3 set up procedure is as follows:

1. Select Channel 1 from the main menu.
2. Select Bridge type FB v opp.
3. Select Gauge Factor Scaling units mV/V.
4. Select Balance, Chan: 1, and then Disable.

Important! If auto balance or manual balance is chosen, the settings for one load cell will carry over to the next. In addition, it is only possible to use the auto or manual setting when the load cell has no load on it. Auto balance must not be initiated with a load cell already under load.

5. The readings will be in mV/V. The linear gauge factor, given by the calibration sheet in engineering units, can be multiplied by 4000 to convert mV/V to engineering units.

For more information, see the P3 instruction manual.

4. DATA REDUCTION

4.1 LOAD CALCULATION WHEN READING DIGITS ON THE GK-502

The basic units utilized by GEOKON for measurement and reduction of data from Model 3000 Load Cells when read using the GK-502 readout box are digits. The calculation of digits is based on the following equation:

$$\text{Digits} = \text{mV}/\text{V} \times 4000$$

EQUATION 1: *Digits Calculation*

Where:
mV = The output of the Wheatstone bridge circuit in millivolts
V = The excitation supplied to the Wheatstone bridge circuit in volts

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 initial no-load reading (R_0) is 164 digits (regression zero reading can be found on the calibration sheet). The current reading (R_1) is 2050 digits. The calibration factor (G) is 148.7 lbs/digit. The load change is:

$$L = (2050 - 164) \times 148.7$$

$$L = 280448 \text{ lbs}$$

Note that increasing (positive) readings indicate increasing load.

The equations assume a linear relationship between load and strain readings, 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".

4.1.2 POLYNOMIAL CALCULATION

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

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

EQUATION 3: *Polynomial Load 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 "L" 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 load (L).

EXAMPLE:

The given polynomial gauge factors on the calibration are:

A = -0.000286

B = 150

The initial no-load reading (R_0) is 164 digits. The current reading (R_1) is 2050 digits.

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

$$0 = AR_0^2 + BR_0 + C$$

$$0 = -0.000286 \times 164^2 + 150 \times 164 + C$$

$$0 = 24592.308C$$

$$C = -24592.308$$

The load change is:

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

$$L = -0.000286 \times 2050^2 + 150 \times 2050 + (-24592.308)$$

$$L = 281706 \text{ lbs}$$

Note that increasing (positive) readings indicate increasing load.

4.2 LOAD CALCULATION WHEN READING THE OUTPUT IN MV/V ON A MODEL P3 READOUT BOX

The load is calculated using the following equation:

$$L = J(M_1 - M_0)$$

EQUATION 5: *Load Calculation Using mV/V*

Where:
J = The mV/V gauge factor equal to the linear gauge factor G * 4000.
M_1 = The current reading in mV/V.
M_0 = The no-load field zero reading in mV/V.

In the example in the calibration sheet shown in Appendix C:

J = 148.7 x 4000 = 594, 600 lb/mV/V.

Alternatively, the value for the Full Scale mV/V can be used following the P3 instructions.

4.3 OPTIONAL CALCULATIONS

4.3.1 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*

4.4 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

Should difficulties arise, consult the possible solutions shown below. Visit geokon.com/Technical-Support for additional troubleshooting help.

Problems with the load cell are usually associated with cable damage or moisture getting into the system. Both problems can be minimized by protecting the cable from damage, by visual inspection of the cable in the event that problems arise, and by keeping the plug clean and dry at all times. **Never carry the load cell by the cable.**

Check the cable for damage such as pulling out of the load cell or connector, crushed spots, cuts or kinks. If the cable is damaged, splice according to the instructions in Section 2.3.

Check the load cell wiring. The wiring diagram and pinout are shown in Appendix B. If the load cell is working properly, the resistances between the various pins should be as shown in the table below.

	Load Cell Bearing Surface / Gauge Quantity			
Pins	**Up to 4" (4 Gauge)**	**4.5 to 10" (8 Gauge)**	**11 to 16" (12 Gauge)**	**Over 16" (16 Gauge)**
A and B	260 Ω	525 Ω	790 Ω	1050 Ω
A and C	260 Ω	525 Ω	790 Ω	1050 Ω
A and D	350 Ω	700 Ω	1050 Ω	1400 Ω
B and C	350 Ω	700 Ω	1050 Ω	1400 Ω
B and D	260 Ω	525 Ω	790 Ω	1050 Ω
B and J	0 Ω	0 Ω	0 Ω	0 Ω
C and D	260 Ω	525 Ω	790 Ω	1050 Ω
C and K	0 Ω	0 Ω	0 Ω	0 Ω
F and any other pin	Infinite	Infinite	Infinite	Infinite

TABLE 2: *Load Cell Resistance*

Failure of the load cell to agree with the load as indicated by a hydraulic jack could be caused by one or more of the factors discussed in Section 1.2 and Appendix D.

APPENDIX A. SPECIFICATIONS

A.1 RESISTANCE LOAD CELL SPECIFICATIONS

Available Ranges[1]	100, 150, 200, 300, 500, 600, 1000, 1500, 2000 kip
Rated Capacities[2]	100 kN to 10,000 kN
Accuracy[3]	±0.5% F.S.
Output	1.5 mV/V to 2.5 mV/V @ F.S.
Linearity	0.5% F.S.
Resolution[4]	0.025% F.S.
Repeatability[5]	0.1% F.S.
Temperature Effect	0.02% F.S./°C
Temperature Range	-20 °C to +80 °C
Overrange[6]	150% F.S.
Input Resistance	350, 700, 1050, or 1400
Output Resistance	350, 700, 1050, or 1400
Excitation Voltage	2 to 15 VAC or DC
Maximum Excitation Voltage	30 V
Internal Diameters[7]	solid, 25, 50, 75, 100, 125, 150, 200, 250 mm
Cable Type[8]	Three twisted pair (six conductor) 22 AWG Foil shield, PVC jacket, nominal OD=9.5 mm (0.375")

TABLE 3: *Model 3000 Resistance Load Cell Specifications*

Note:

[1] Other ranges available on request.

[2] Other capacities available on request. Calibrations that exceed GEOKON's NIST traceable capacity of approximately 10,675 kN are subcontracted to an accredited testing laboratory.

[3] The accuracy of the testing machine used to calibrate the cells is ±¼% F.S. traceable to NIST. The system accuracy depends on end loading conditions as described in the text of this manual. If field conditions are well duplicated during actual calibration the accuracy should be within ±0.5% F.S., failure to duplicate conditions can cause calibration variations of ±20% in extreme cases.

[4] Minimum, depends on the readout instrument and technique.

[5] Repeatability under the same loading conditions. This does not take into account hysteresis and any changes in the loading conditions.

[6] With no calibration shift. The maximum overrange without failure is 200% F.S. for aluminum cells, 300% to 400% F.S. for steel cells, but both the no-load zero and the calibration may change if the load exceeds 150% F.S.

[7] Other capacities and diameters available on request.

[8] Other cable types available.

APPENDIX B. WIRING AND CONNECTOR PINOUTS

The GK-502 is set up for remote sense of the excitation voltage at the load cell, which requires a six-conductor cable (three twisted pairs). If the load cell is not set up for remote sense and only has four conductors, then it will be necessary to modify the cable plug so that pins J and B and pins K and C are shorted together, otherwise the load cell cannot be read.

The P3 readout box will not read remote sense therefore load cells that have been wired for remote sense must be rewired at the connector for non-remote sense.

B.1 WIRING DIAGRAM WITH REMOTE SENSE (GK-502 READOUT)

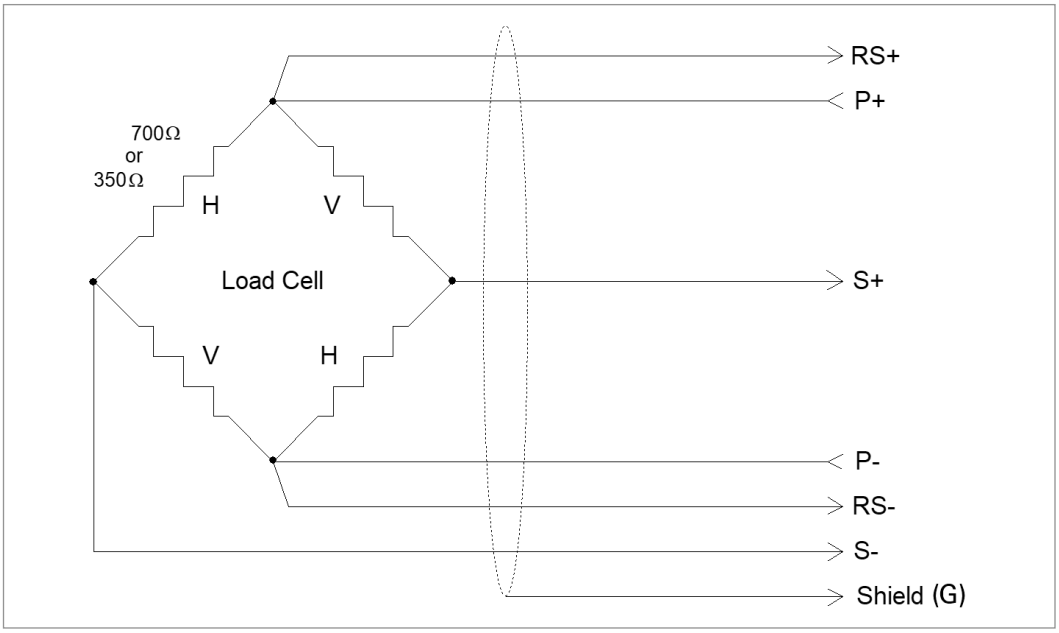


FIGURE 5: *Remote Sense (GK-502) Wiring*

B.2 WIRING FOR USE WITH THE GK-502 READOUT BOX

10-Pin Bulkhead	Amp (6-pin)	Circuit Label	Description	Internal Load Cell Wiring	Purple Cable
A	C	S-	Bridge Output -	White	White's Black
B	B	P+	Bridge Excitation +	Red	Red
C	A	P-	Bridge Excitation -	Black[1]	Red's Black
D	D	S+	Bridge Output +	Green[1]	White
E		NC	No Connection		N/C
F	E	G	Ground for Shield		Bare Drain Wires
G		NC	No Connection		N/C
H		NC	No Connection		N/C
J		RS+	Remote Sense +	Red[2]	Green
K		RS-	Remote Sense -	Black[2]	Green's Black

TABLE 4: *GK-502 Wiring*

Note:

[1] Green and black wires switched on GEOKON load cells prior to serial number 1190.

[2] Non-remote sense is optional and must be specified at the time of ordering.

B.3 WIRING DIAGRAM WITH P3 READOUT

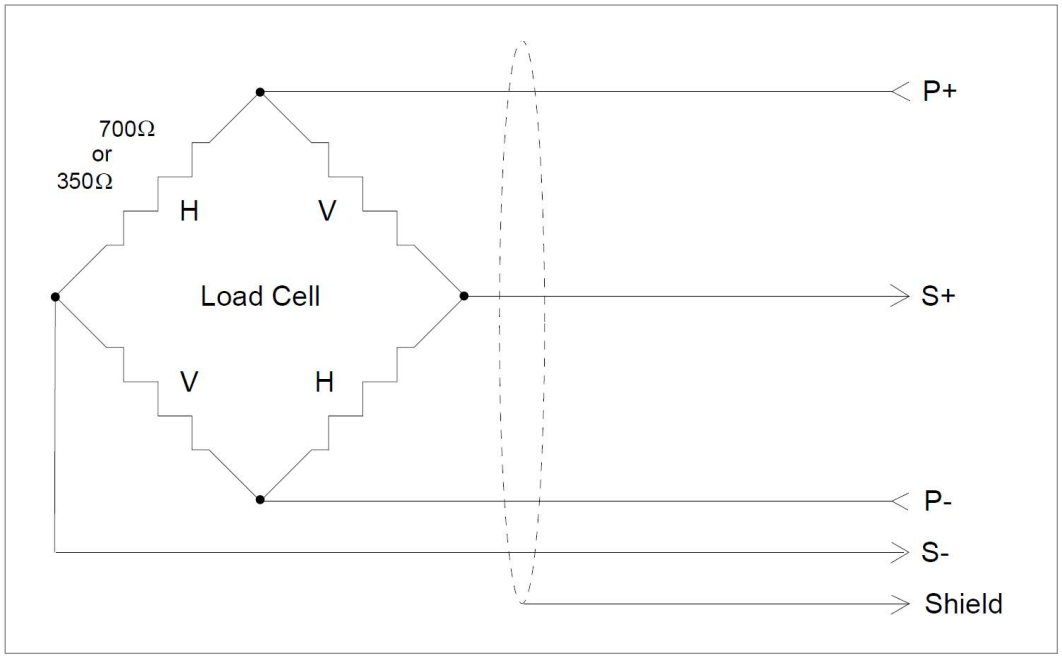


FIGURE 6: *P3 Wiring*

B.4 P3 CONNECTION

10-Pin Bulkhead	P3 Label	Description	Purple Cable
B	P+	Bridge Excitation +	Red
C	P-	Bridge Excitation -	Red's Black
A	S-	Bridge Output -	White's Black
D	S+	Bridge Output +	White
	D120	No Connection	N/C
	D350	No Connection	N/C
	D1K	No Connection	N/C
F	Shield	Shield Connection	Bare Drain Wires

TABLE 5: *P3 Wiring*

APPENDIX C. TYPICAL CALIBRATION REPORT

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Load Cell Calibration Report

Model Number: 3000-600-5 Calibration Date: April 19, 2012

Serial Number: 1131479 Calibration Instruction: CI-3000GP

Max. Range (lbs): 600000 Technician:

Cable Length: 40 feet

Initial Cycling Data

Load (lbs):	0	0	900000	0
Reading:	160	173	6218	173

Calibration

Applied Load in lbs	Readings from GK-501 or GK-502 readout box				Linearity % Max Load	Polynomial Error (%FS)
	Cycle 1	Cycle 2	Average	Change		
0	173	170	172		0.19	0.08
120000	965	960	963	791	-0.21	-0.19
240000	1779	1779	1779	816	0.03	0.11
360000	2585	2577	2581	802	-0.09	-0.01
480000	3393	3391	3392	811	0.01	0.03
600000	4204	4199	4202	810	0.08	-0.03
0	167	167	167			

GK-501 or GK-502 Readout

Linear Gage Factor (G): 148.7 lbs/digit **Regression Zero (R_0):* 164**

Polynomial Gage Factors: **A: -0.000286** **B: 150** **C:**

Polynomial, $L = AR_1^2 + BR_1 + C$ **Full Scale mV/ V: 1.009 mV/ V**

Calculate C by setting L=0 and R_1 = initial field zero reading in the polynomial equation

* Note: The above calibration uses a linear regression method. The Zero Reading shown is ideal for straight line computation and does not usually agree with the actual no-load reading.

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: *Model 3000 Calibration Report*

APPENDIX D. LOAD CELL CALIBRATIONS: EFFECTS OF BEARING PLATE WARPING

D.1 INTRODUCTION

Load cells used to measure loads during testing of tiebacks, driven piles, and drilled shafts give calculated loads that are frequently in disagreement with loads calculated based on hydraulic jack pressure and piston area. Because of this, there is a general lack of confidence in load cell data and the fault is often ascribed to manufacturing defects, or to improper, inaccurate calibration procedures.

Nevertheless, it is well-known throughout the industry that load cell readings can be affected profoundly by eccentric loading, uneven and/or warped bearing plates, or frictional effects on the bearing surfaces. The purpose of this technical note is to provide some insight into these effects.

D.2 LOAD CELL CALIBRATION PROCEDURES

The usual calibration procedure is to use a testing machine to apply a load to a load cell. The measured load cell output is then correlated against the known applied load as measured by the testing machine. Usually, the testing machine has a hydraulic pressure applied to a piston of known cross section area. The testing machine is checked out periodically by running tests on a load cell traceable to NIST. Generally there is little doubt about the accuracy of the testing machine. Accuracies of ¼% FS, ½% FS, or 1% FS are normal.

The calibration tests are usually performed between large, flat, parallel platens in the testing machine (sometimes with the addition of a spherical seat). The calibration is performed in this manner so that there is little or no eccentric loading, and no bending of the platens, only the elastic compression in the zone immediately bearing against the load cell.

D.3 FIELD ARRANGEMENT

Such a state of affairs may not exist on the job site, since the bearing surfaces next to the load cell are usually much less rigid and more at risk to bending.

This bending is particularly apparent if there is a mismatch in size between the load cell and the hydraulic jack. If the hydraulic jack is larger than the load cell there is a tendency for it to try to wrap the intervening bearing plate around the load cell. If the hydraulic jack is smaller than the load cell it will try to push the intervening bearing plate through the hole in the load cell.

Thicker bearing plates will bend less, but the effect will never be entirely eliminated. The consequence of this bending can be quite large since the effect on the load cell is to cause it to either barrel out at its midsection if the jack is too small, or pinch in at its midsection if the jack is too big. For electrical resistance strain gauge load cells, the gauges are usually located on the outer surface of the load bearing cylinder at its midsection.

D.4 EFFECTS OF JACK SIZE ON LOAD CELL READING

A series of tests were conducted in a testing machine to investigate the magnitude of the effect of jack size on load cell readings.

Load cell bearing surface: 102 mm (4") ID, 146 mm (5.75") OD

Simulated jack A bearing surface: 52 mm (2") ID, 102 mm (4") OD

Simulated jack B bearing surface: 102 mm (4") ID, 146 mm (5.75") OD

Simulated jack C bearing surface:152 mm (6") ID, 203 mm (8") OD

Maximum applied load: 150 tons

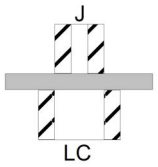
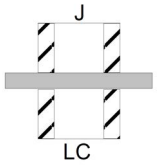
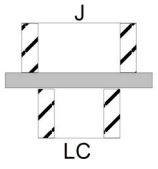
Jack		Load Cell response to applied load (100%)	
		1" thick plate	2" thick plate
A (smaller)		108%	102%
B (same size)		100%	100%
C (bigger)		96%	98%

TABLE 6: *Effects of Jack Size on Readings*

It can be seen from the results that if the jack is smaller than the load cell, the load cell will over-register, while a jack bigger than the load cell will cause the load cell to under-register. The effect is bigger if the bearing plate between jack and load cell is thinner.

The correct bearing plate thickness will depend on the extent of the mismatch between jack and load cell. However, as a rough rule of thumb the following thicknesses should be required:

Up to 100-200 kip load: 25 mm (1") thick

Up to 400 kip load: 38 mm (1.5") thick

Up to 1000 kip load: 51 mm (2") thick

Up to 2000 kip load: 76 mm (3") thick

D.5 CONCLUSION

The consequences of the above would seem to indicate that **for best results the load cell calibration should be performed in the field with the actual hydraulic jack that will be used**. Alternatively, if the calibration is done in the laboratory, the load cell and the jack should be placed in the testing machine at the same time. Failing that, the load cell should be loaded through a ring, having the same dimensions as the bearing surface of the hydraulic jack, positioned on the other side of a bearing plate of the correct thickness. In this way, some of the variables affecting the agreement between load cell readings and hydraulic jack readings can be removed and the agreement should be that much closer.

This technical note has addressed only the subject of the size mismatch between load cells and hydraulic jacks. Other factors affecting the agreement between load cell readings and hydraulic jack load are important, thus frictional losses within the hydraulic jack can cause under-registering of jack load indications by as much as 15%. (Dunnicliff 1988' Section 13.2.6)

Also annular style load cells are susceptible to end effects and eccentrically applied loads. The height of the load cell should exceed four times the wall thickness of the annulus and at least four strain gauges should be used (Dunnicliff 1988' Section 13.2.6) increasing to eight or 12 in number as the size of the load cell increases.

References:

J. Dunnicliff. 1988. Geotechnical Instrumentation for Monitoring Field

Performance, John Wiley & Sons, New York, NY: 577pp.

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