Model 3400

Semiconductor Piezometer

Instruction Manual

GEOKON®

Document Revision: J.1 | Release Date: 1/28/25

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 that wear or are damaged by misuse are not warranted. This includes fuses and batteries.

GEOKON manufactures scientific instruments whose misuse is potentially dangerous. The instruments are intended to be installed and used only by qualified personnel. There are no warranties except as stated herein. There are no other warranties, expressed or implied, including but not limited to the implied warranties of merchantability and of fitness for a particular purpose. GEOKON is not responsible for any damages or losses caused to other equipment, whether direct, indirect, incidental, special or consequential which the purchaser may experience as a result of the installation or use of the product. The buyer's sole remedy for any breach of this agreement by GEOKON or any breach of any warranty by GEOKON shall not exceed the purchase price paid by the purchaser to GEOKON for the unit or units, or equipment directly affected by such breach. Under no circumstances will GEOKON reimburse the claimant for loss incurred in removing and/or reinstalling equipment.

Every precaution for accuracy has been taken in the preparation of manuals and/or software, however, GEOKON neither assumes responsibility for any omissions or errors that may appear nor assumes liability for any damages or losses that result from the use of the products in accordance with the information contained in the manual or software.

TABLE OF CONTENTS

1. INTRODUCTION

GEOKON Model 3400 Semiconductor Piezometers are intended for dynamic measurements of fluid and/or pore water pressures in standpipes, boreholes, embankments, pipelines, pressure vessels, reservoirs, etc. They are also used for static pressure movement where the readout system is incompatible with vibrating wire type sensors. The standard piezometer assembly is shown in Figure 1.

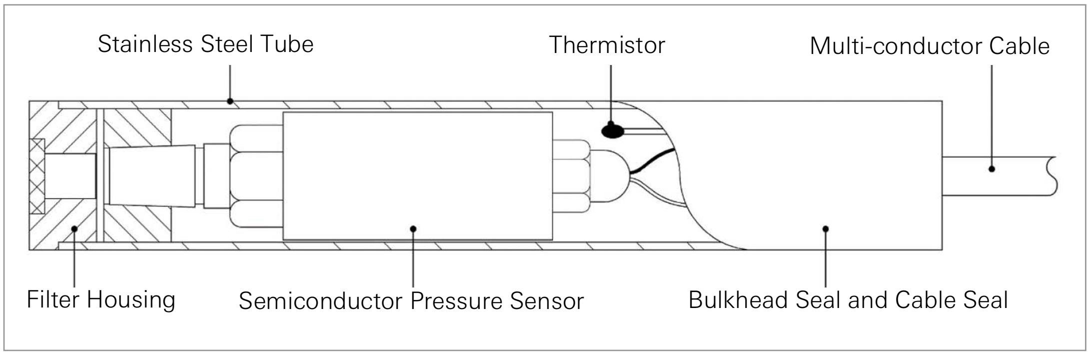

FIGURE 1: *Model 3400 Semiconductor Piezometer Assembly*

Pressure sensors with voltage (0-100 mV or 0-5 VDC) or current (4-20 mA) output are available for dynamic readout capability. Consult the factory for additional information.

The sensor is installed inside a 1.25" (32 mm) diameter 316 stainless steel tube. At one end of this tube is a filter housing to allow the passage of water while preventing the entry of soil particles. At the other end is located a bulkhead seal and cable entry seal to prevent water from reaching the backside of the sensor. A thermistor included inside the main housing allows the measurement of temperature.

The readout cable for remote sense uses four individually shielded pairs of cable. Two pairs are connected to the semiconductor bridge, one pair is connected to a thermistor, and one pair is used for remote sensing when there are long cables (>50 m). For sensors with 4-20 mA outputs, a two pair construction is used. Low pressure models may also be vented to the atmosphere through a vent tube inside the cable. Venting of the sensor is necessary if the effects of barometric pressure changes on the sensor are to be eliminated.

With vented units, the outer end of the vent tube is connected to a desiccant chamber to prevent moisture from migrating to the sensor interior. A 2.5 ft length of blue cable is spliced at the end of the tubing, this allows for a standard connection to a readout or datalogger as needed.

FIGURE 2: *Vented Semiconductor Piezometer*

2. PRIOR TO INSTALLATION

2.1 PRELIMINARY TESTS

Before installation, check the sensor for proper functioning. The sensor electrical leads are connected to a multimeter and power supply (see Section 4 and Appendix C) and the zero reading given on the calibration report is now compared to a current zero reading. The two readings should not differ by more than 1% F.S. after due regard to corrections made for different temperatures, barometric pressures and height above sea level.

Apply a pressure or vacuum to the sensor and check that the readout responsive.

Checks of the insulation can also be made using an ohmmeter. Resistance between any conductor and the shield should exceed 50 megohms. The thermistor inside the cell can also be checked.

2.2 ESTABLISHING AN INITIAL ZERO READING

Note: It is imperative that an accurate initial zero reading be obtained for each sensor, as this reading will be used for all subsequent data reduction.

The following procedures are important.

1. Remove the filter housing completely (preferred) or make sure that the filter stone is saturated and that the space between the filter and sensor diaphragm is filled with water.
2. Lower the sensor into the borehole or well until it is just above the water level.
3. Allow 15 to 20 minutes for the temperature to stabilize before taking the reading.

2.3 SATURATING FILTER TIPS

Warning! Do not allow the sensor to freeze once the filter stone has been saturated!

See Section 3.9 for information about protecting the sensor from freezing.

Most filter tips can be removed for saturation and then reassembled. To maintain saturation, the unit should be kept underwater until installation. If the sensor is used in a standpipe where it will be raised and lowered frequently, the filter housing may loosen over time, and a permanent filter assembly may be required. The removable filter may be fixed permanently by prick punching the sensor tube approximately 1/16" to 1/8" behind the filter assembly joint.

Salts in the water can be deposited into the filter stone causing it to become clogged if it is allowed to dry out completely. Filter stones may be replaced with screens for standpipe installations. Screens available from GEOKON are less likely than standard filters to collect salt and become clogged.

2.3.1 SATURATING STANDARD FILTERS

For accurate results, total saturation of the filter is necessary. As the sensor is lowered into the water, water is forced into the filter, compressing the air in the space between the filter stone and the pressure sensitive diaphragm. After a period, this air will dissolve into the water, filling the filter and the space above it entirely with water.

To speed up the saturation process, remove the filter from the sensor by carefully twisting and pulling on the filter housing assembly (or unscrewing the point of the sensor for model 3400DP Drive Point series). Hold the sensor with the filter facing up and fill the space above the diaphragm with water. Slowly replace the filter housing, allowing the water to squeeze through the filter stone as it is installed.

2.3.2 SATURATING HIGH AIR ENTRY CERAMIC FILTERS

Because of the high air entry characteristics of the ceramic filter, de-airing is particularly important. Different air entry values require different saturation procedures.

ONE BAR FILTERS

1. Remove the filter from the sensor by carefully twisting and pulling on the filter housing assembly.

2. Boil the filter assembly in de-aired water.
3. Reassemble the sensor under the surface of a container of de-aired water. Use a readout box while slowly installing the filter to monitor the diaphragm pressure. If the sensor begins to over-range, allow the pressure to dissipate before pushing further.
4. Be sure that no air is trapped in the sensor cavity.

TWO BAR AND HIGHER FILTERS

The proper procedure for de-airing and saturating these filters is somewhat complex; therefore, it is recommended that saturation be done at the factory by GEOKON. If saturation must be done in the field, carefully follow the instructions below:

1. Place the assembled sensor, filter down, in a vacuum chamber that has an inlet port at the bottom for de-aired water.
2. Close off the water inlet and evacuate the chamber. The sensor should be monitored while the chamber is being evacuated.
3. When maximum vacuum has been achieved, allow de-aired water to enter the chamber until it reaches an elevation a few inches above the sensor filter.
4. Close off the inlet port.
5. Release the vacuum.
6. Observe the sensor output. It may take up to 24 hours for the filter to completely saturate and the pressure to rise to zero.
7. After saturation, the sensor should be kept in a container of de-aired water until installation. If de-aired at the factory a special cap is applied to the sensor to maintain saturation.

3. INSTALLATION

Establish a zero reading and saturate the filter stone by following the steps outlined in Section 2.2 and Section 2.3 before proceeding to installation.

Warning! Do not allow the sensor to freeze once the filter stone has been saturated!

3.1 INSTALLATION IN STANDPIPES OR WELLS

1. Establish a zero reading and saturate the filter stone by following the steps outlined in Section 2.2 and Section 2.3.

Warning! Do not allow the sensor to freeze once the filter stone has been saturated!

2. Mark the cable where the top of the well or standpipe will reside once the sensor has reached the desired depth. (The sensor diaphragm is located 3/4 of an inch above the tip of the sensor.)
3. Lower the sensor into the standpipe/well.
4. Be sure the cable is securely fastened to prevent the sensor from sliding further into the well and causing an error in the readings.

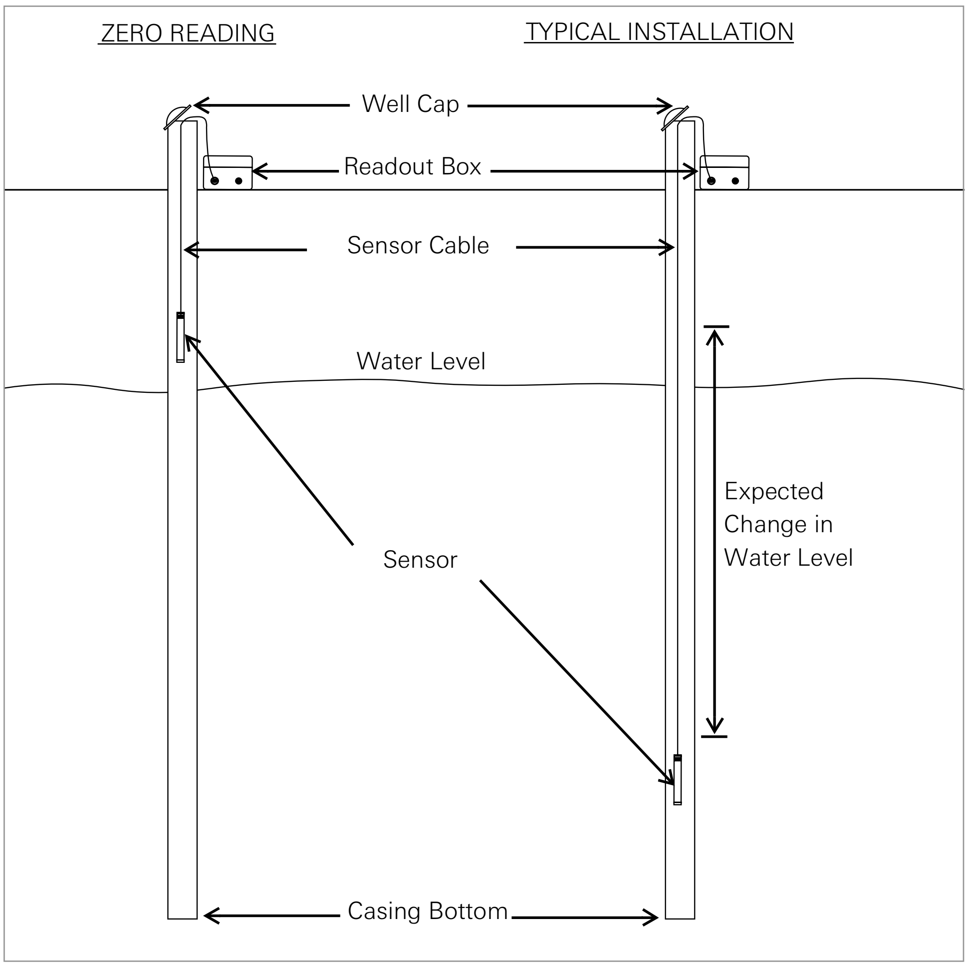

FIGURE 3: *Typical Level Monitoring Installation*

It is not recommended that sensor be installed in wells or standpipes where an electrical pump or cable is nearby. Electrical interference from these sources can cause unstable readings. If unavoidable, it is recommended that the sensor be placed inside a piece of steel pipe. In situations where packers are used in standpipes, special care should be taken to avoid cutting the cable jacket with the packer, as this could introduce a possible pressure leak in the cable.

3.2 INSTALLATION IN BOREHOLES

GEOKON sensors can be installed in cased or uncased boreholes, in either single or multiple sensor configurations. If pore pressures in a particular zone are to be monitored, careful attention must be paid to the borehole sealing technique.

The borehole should extend six to 12 inches below the proposed sensor location. For installation methods A and B (below), if boreholes are drilled without using drilling fluid (mud), this drilling fluid should be of a type that degrades rapidly with time. Wash the borehole clean of drill cuttings.

Three methods of isolating the zone to be monitored are detailed below.

INSTALLATION A

Backfill the borehole with clean fine sand to a point at least six inches below the desired sensor tip location. The sensor can then be lowered into position. While holding the sensor in position, (a mark on the cable is helpful), fill the borehole with clean fine sand to a point at least six inches above the sensor.

Immediately above the area filled with clean fine sand, known as the "collection zone", the borehole should be sealed by an impermeable bentonite cement grout mix, or with alternating layers of bentonite and sand backfill, tamped in place for approximately one foot, followed by cement-bentonite grout (see Figure 4).

If multiple sensors are to be used in a single hole, the bentonite and sand should be tamped in place below and above the upper sensors, as well as at interval between the collection zones. When using tamping tools special care should be taken to ensure that the sensor cable jackets are not cut during installation, as this could introduce a possible pressure leak in the cable. For some installations, it may be cost effective to use a cement-bentonite grout between the multiple collection zones. It is recommended to hydrate the bentonite seals above and below the collection zones before placement of the grout.

INSTALLATION B

The borehole is filled from the collection zone upwards with an impermeable cement-bentonite grout. To keep the granular filter zone intact, care should be taken with this method to ensure that the grout does not bleed into the collection zone.

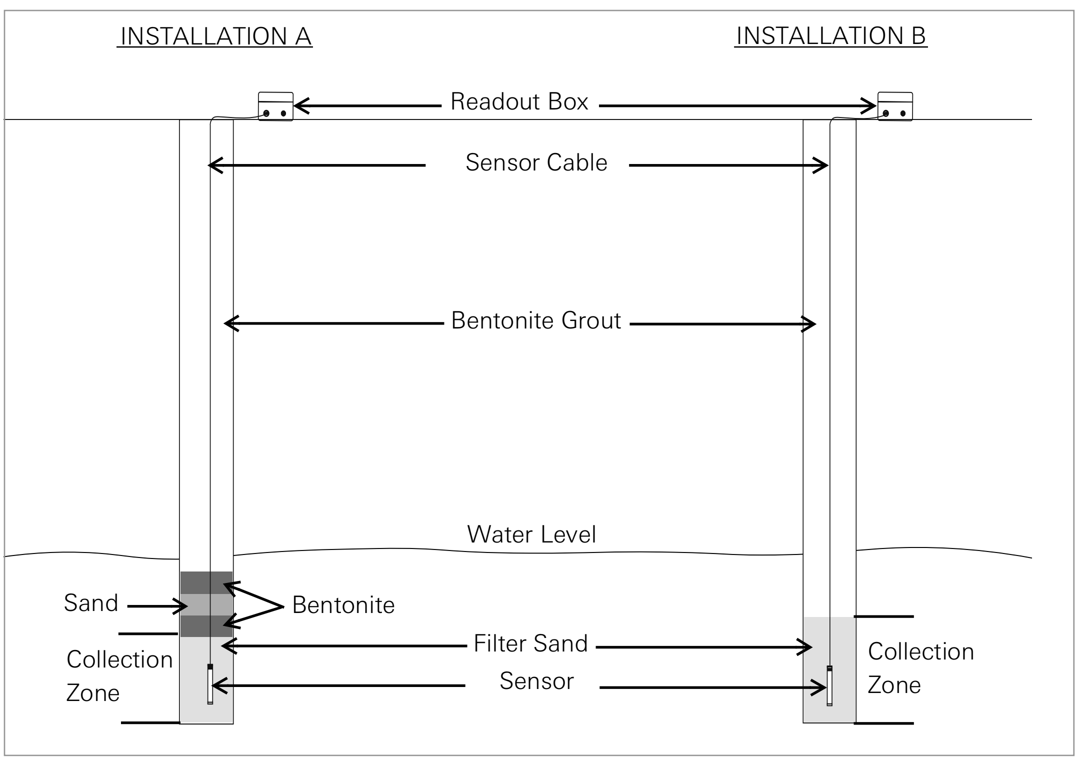

FIGURE 4: *Typical Borehole Installations*

INSTALLATION C

Since the sensor is essentially a no-flow instrument, collection zones of appreciable size are not required. The sensor can be placed directly in contact with most materials, provided that the fines are not able to migrate through the filter. As such, it is not necessary to provide collection zones of sand, the sensor can be grouted directly into the borehole.

A cement-bentonite grout mix is suggested for backfilling a borehole. The cement-bentonite grout uses any kind of bentonite powder combined with Type I or Type II Portland cement. The exact amount of bentonite needed will vary.

Grout mixtures should be determined and adjusted to be of similar parameters to the surrounding soil. Throughout the depth of a borehole, the surrounding soil will typically not be all of the same strength and permeability. However, the use of several types of grout mixes within the same borehole may not be cost effective and practical. Unless it is necessary to do so, identify one type of grout mix that would be applicable to the entire length of the borehole.

The table below shows two possible mixes for strengths of 50 psi and 4 psi.

	50 PSI Grout for Medium to Hard Soils		4 PSI Grout for Soft Soils	
	Amount	**Ratio by Weight**	**Amount**	**Ratio by Weight**
Water	30 gallons	2.5	75 gallons	6.6
Portland Cement	94 lb. (one sack)	1	94 lb. (one sack)	1
Bentonite	25 lb. (as required)	0.3	39 lb. (as required)	0.4
Note:	The 28-day compressive strength of this mix is about 50 psi, similar to very stiff/hard clay. The modulus is about 10,000 psi.		The 28–day strength of this mix is about 4 psi, similar to very soft clay.	

TABLE 1: *Cement / Bentonite / Water Ratios*

Perform the following steps to mix the cement-bentonite grout:

1. Add the measured amount of clean water to the barrel then gradually add the cement in the correct weight ratio. Mix the cement thoroughly into the water.

   Tip: The most effective way of mixing the two substances is to use a drill rig pump to circulate the mix in a 50 to 200 gallon barrel or tub.

2. While mixing, slowly add the bentonite powder so that clumps do not form. Keep adding bentonite until the watery mix turns to a slimy consistency. Continue mixing for approximately five to 10 minutes to allow the grout to thicken.
3. Add more bentonite as required until it is a smooth, thick cream, similar to pancake batter, which is as heavy as it is feasible to pump.

When pumping grout (unless the tremie pipe is to be left in place), withdraw the tremie pipe after each batch, by an amount corresponding to the grout level in the borehole.

Warning! If the grout is pumped into the hole, rather than tremie piped, there is a danger that the sensor will be over-ranged and damaged. Grout can also segregate if pumped into top of borehole, and may not fully backfill and encapsulate the sensor. It is good practice to read the sensor while pumping.

For more details on grouting, refer to "Piezometers in Fully Grouted Boreholes" by Mikkelson and Green, FMGM proceedings Oslo 2003. Copies are available from GEOKON.

3.3 INSTALLATION IN FILLS AND EMBANKMENTS

GEOKON sensors are normally supplied with direct burial cable suitable for placement in fills such as highway embankments and dams, both in the core and in the surrounding materials.

For installations in non-cohesive fill materials, the sensor may be placed directly in the fill, or, if large aggregate sizes are present, in a saturated sand pocket in the fill. If installed in large aggregate, additional measures may be necessary to protect the cable from damage.

Cables are normally installed inside shallow trenches with the fill material consisting of smaller size aggregate. This fill is carefully hand compacted around the cable. Bentonite plugs are placed at regular intervals to prevent migration of water along the cable path. In high traffic areas and in materials that exhibit pronounced "weaving", heavy-duty armored cable should be used.

Depending on the type of filter installed on the sensor the material used and filter contact may vary.

STANDARD FILTER

In partially saturated fills (if only the pore air pressure is to be measured), the standard tip is satisfactory. It should be noted that the standard tip measures the air pressure when there is a difference between the pore air pressure and the pore water pressure. The difference between these two pressures is due to the capillary suction in the soil. The consensus is that the difference is normally of no consequence to embankment stability.

The standard tip is suitable for most routine measurements, and both the standard and high air entry installations shown in Figure 5 may be used.

HIGH AIR ENTRY (HAE) FILTER

In fills such as impervious dam cores, where subatmospheric pore water pressure may need to be measured, (as opposed to the pore air pressure), a ceramic tip with a high air entry value is often used. This type of filter should be carefully placed in direct contact with the compacted fill material. (See Figure 5).

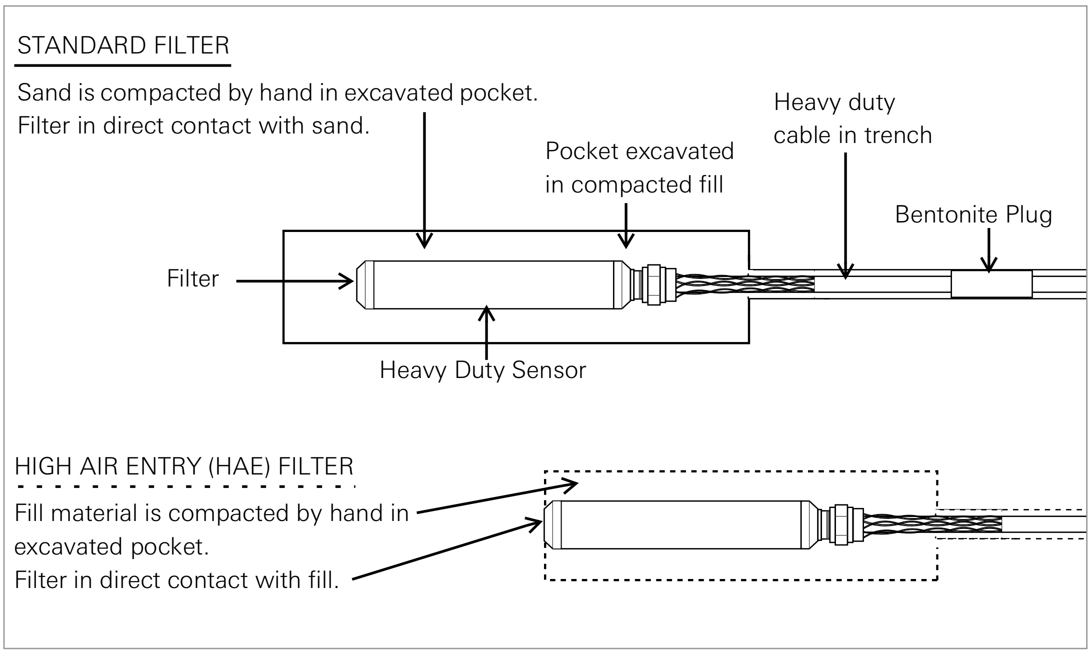

FIGURE 5: *Standard and High Air Entry Filters*

3.4 INSTALLATION BY PUSHING OR DRIVING INTO SOFT SOILS

The Model 3400DP Drive Point Semiconductor Piezometer is designed to be pushed into soft soils. In soft soils, it can be difficult to keep a borehole open. The 3400DP may eliminate the need for a borehole altogether. The unit is connected directly to the drill rod (AW, EW, or other) and pressed into the ground, either by hand or by means of the hydraulics on the rig (see Figure 6). GEOKON suggests these units not be driven into the soil, since there is a possibility that the driving forces may shift the zero reading.

The ground conditions need to be relatively soft for the 3400DP to be effective. Soft soils (like clays or silts) with SPT blow counts under 10 are ideal. In stiffer soils, it is possible to drill a hole and then push the 3400DP only a few feet below the bottom of the hole. If the soil is too stiff, the sensor may overrange or break.

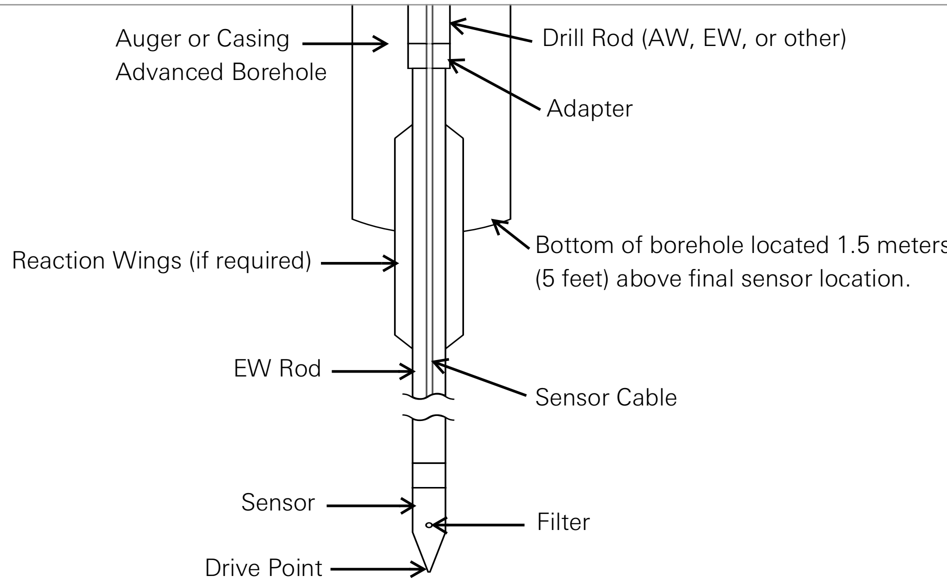

FIGURE 6: *Typical Soft Soils Installation*

The sensor should be connected to a readout box and monitored during the installation process. If pressures reach or exceed the calibrated range, the installation should be stopped, and the pressure allowed to dissipate.

The drill rod can be left in place or it can be removed. If it is to be removed, a special five-foot section of EW (or AW) rod with reaction wings and a left-hand thread are attached directly to the sensor tip. This section is detached from the rest of the drill string by rotating the string clockwise. The reaction wings prevent the EW rod from turning. A LH/RH adapter is available from GEOKON. This adapter is retrieved along with the drill string.

3.5 MODEL 3400H SEMICONDUCTOR PIEZOMETER

When connecting the Model 3400H Semiconductor Piezometer to external fittings, the fitting should be tightened into the 1/4-18 NPT female port by placing a wrench on the flats provided on the sensor housing. Avoid tightening onto a closed system; the process of tightening the fittings could overrange and permanently damage the sensor. If in doubt, attach the sensor leads to a readout box and take readings while tightening. For an easier and more positive connection to the sensor, PTFE (plumber's) tape on the threads is recommended.

3.6 SPLICING AND JUNCTION BOXES

Cable splicing should be kept to a minimum since changes in cable resistance can cause changes in calibration if remote sensing techniques or 4-20 mA output are not in use.

The Model 3400 utilizes a semiconductor sensor and, as such, has low-level output signals. **If cables are damaged or improperly spliced, the outputs can be seriously degraded. Therefore, it is absolutely necessary to provide a high degree of cable protection. If cables must be spliced, only recognized high quality techniques should be used.**

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.** Splice kits recommended by GEOKON incorporate casts that are placed around the splice and 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.

Junction boxes and terminal boxes are available from GEOKON for all types of applications. In addition, portable readouts and dataloggers are also available. Contact GEOKON for specific application information.

3.7 ELECTRICAL NOISE

Care should be exercised when installing sensor 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 with AC power lines. The sensor cables will pick up the 50 or 60 Hz (or other frequency) noise from the power cable and this will likely cause a problem obtaining a stable reading. Contact the factory concerning filtering options available for use with the GEOKON dataloggers and readouts should difficulties arise.

3.8 LIGHTNING PROTECTION

In exposed locations, it is vital that the sensor be protected against lightning strikes. Lightning protection measures available include:

- Placing a Lightning Arrestor Board (Model 4999-12L), in line with the cable, as close as possible to the installed sensor (see Figure 7). These units utilize surge arrestors and transzorbs to protect the sensor. This is the recommended method of lightning protection.
- Terminal boxes available from GEOKON can be ordered with lightning protection built in. The terminal board used to make the sensor connections has provision for the installation of plasma surge arrestors. Lightning Arrestor Boards (Model 4999-12L) can also be incorporated into the terminal box. The terminal box must be connected to an earth ground for these levels of protection to be effective.
- If the sensors will be read manually with a portable readout (no terminal box), a simple way to help protect against lightning damage is to connect the cable leads to a good earth ground when not in use. This will help shunt transients induced in the cable to ground, away from the sensor.

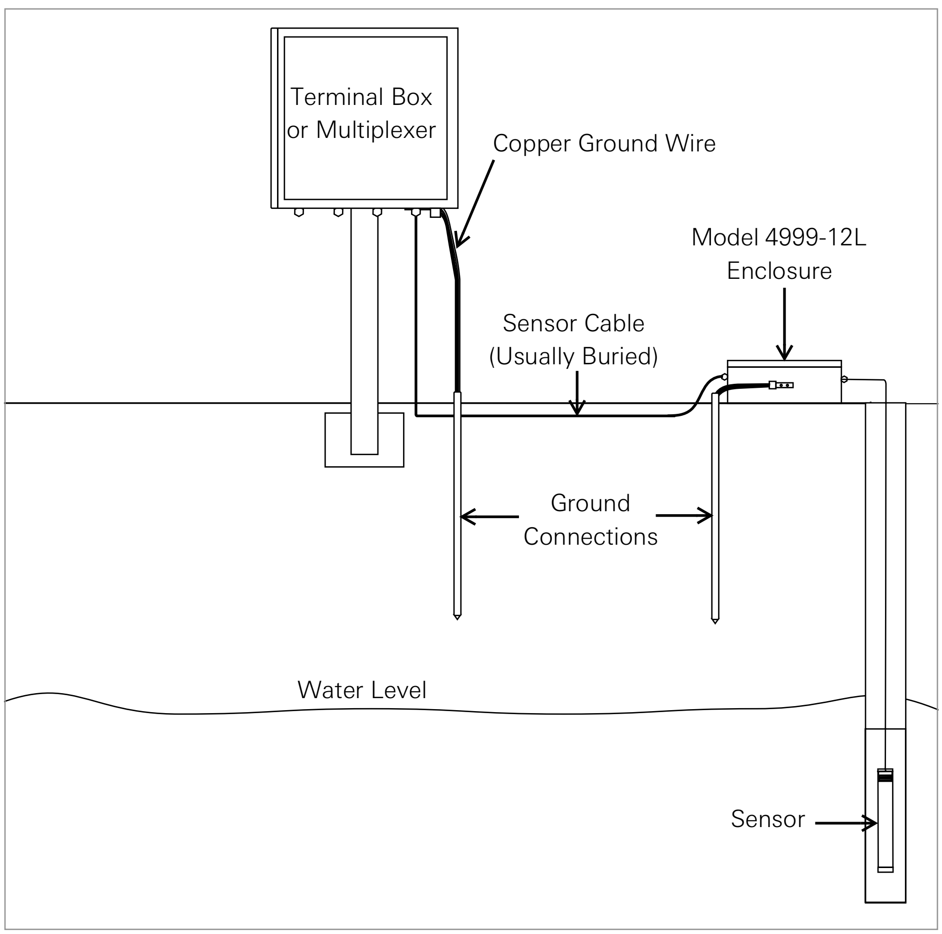

FIGURE 7: *Recommended Lightning Protection Scheme*

3.9 FREEZING PROTECTION

If the water around the sensor freezes this could damage the sensor diaphragm causing a large shift in the zero-pressure reading. If the sensor is to be used in locations that are subject to freezing, GEOKON can provide a special modification that will protect the sensor diaphragm.

4. TAKING READINGS

The Model 3400 uses a semiconductor sensor with an output of either 0-100mV (Model 3400-1), 0-5 Volts (Model 3400-2), or 4-20 mA (Model 3400-3).

For the 0-100mV type, the output voltage is directly proportioned to both pressure and input voltage, therefore it is very important that the input voltage be accurately controlled @ 10 VDC. If any other voltage is used, the data calculation must be adjusted accordingly. The 0-5 volt and 4-20mA sensors require an unregulated input of 24 VDC (7-32 VDC).

Readings are taken with an ohmmeter and VDC regulated power supply, use the applicable wiring chart in Appendix C.

Warning! Incorrect connection may cause permanent and irreparable damage to the sensor.

4.1 COMPATIBLE DATALOGGERS

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

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.

Model 4999 Manual

4.2 MODEL 4999 TERMINAL BOXES

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.

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

4.3 MEASURING TEMPERATURES

Each sensor is equipped with a thermistor for reading temperature. The thermistor gives a varying resistance output as the temperature changes. Appendix C shows which cable conductors are connected to the thermistor. Connect an ohmmeter to the 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 millivolt (mV), Volt (V), or milliamp (mA).

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 mV, V, or mA to pressure the following equation applies:

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

EQUATION 1: *Linear Pressure Calculation*

Where:
G = The gauge factor found on the calibration report, usually in terms of kPa or MPa per mV, V, or mA.

R_1 = The current reading in mV, V, or mA.
R_0 = The initial field zero reading in mV, V, or mA.

As mentioned in Section 4, if reading a **millivolt** sensor using an input voltage other than 10 VDC, the data calculation must be adjusted. To do this, multiply the equation above by $10/V_1$.

EXAMPLE:

The initial reading (R_0) at installation of a Model 3400-1-100 kPa (0-100mV sensor) is 0.500 mV. The current reading (R_1) is 40 mV. Readings were taken with an input voltage of 12 VDC, so for this specific example the input voltage adjustment must be calculated. The calibration factor (G) is 1.0021 kPa/mV. The pressure change is:

$$P = G(R_1 - R_0) \times 10/V_1$$

$$P = 1.0021(40 - 0.500) \times 10/12$$

$$P = 32.99\ \text{kPa}$$

Increasing (positive) readings indicate an increased depth of 3.36 m (11.04’) (if calculating for fresh water) using the engineering units conversion in Section 5.3.2.

5.1.2 POLYNOMIAL CALCULATION

To convert mV, V, or mA to pressure using the polynomial expression the following equation applies:

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

EQUATION 2: *Polynomial Pressure Calculation*

Where:
R_1 = The current reading in mV, V, or mA.
A, B, C = The polynomial gauge factors found on the calibration report.

As mentioned in Section 4, if reading a **millivolt** sensor using an input voltage other than 10 VDC, the data calculation must be adjusted. To do this, find R_P and **substitute R_P in place of R_1** in Equation 2.

$$R_P = R_1 \times 10 / V_1$$

EQUATION 3: *Calculation for Current Reading Adjustment "R_P" when reading in mV*

Where:
R_1 = The current reading in mV.
V_1 = Input voltage when taking the reading.

EXAMPLE:

The given polynomial gauge factors on the calibration are:

A = $5.87E^{-05}$

B = 0.9962

C = -0.4177

The current reading (R_1) of a Model 3400S-1-100 kPa (0-100mV sensor) is 40 mV. Readings were taken with an input voltage of 12 VDC.

First, for this specific example, the input voltage adjustment must be calculated:

$$R_P = R_1 \times 10 / V_1$$

$$R_P = 40 \times 10 / 12$$

$$R_P = 33.33$$

The pressure change is:

$$P = AR_P^2 + BR_P + C$$

$$P = 5.87 \times 10^{-5} \times 33.33^2 + 0.9962 \times 33.33 + (-0.4177)$$

$$P = 32.84 \text{ kPa}$$

Increasing (positive) readings indicate an increased depth of 3.35 m (10.99') (if calculating for fresh water) using the engineering units conversion in Section 5.3.2.

5.2 BAROMETRIC CORRECTION (REQUIRED ONLY ON UNVENTED SENSORS)

If the sensors are unvented, they will respond directly to barometric fluctuations. If a correction is required, it will be necessary to record the barometric pressure at the time of each pressure reading.

The following barometric correction equation is calculated, then afterwards is added to the pressure calculation (Equation 1 or Equation 2):

$$S_{Correction} = (S_1 - S_0) \times F$$

EQUATION 4: *Barometric Correction with Conversion Factor*

Where:
S_1 = The current barometer.
S_0 = The initial field zero barometer.
F = The conversion factor, see below for more detail.

Barometric pressure must be converted to the same engineering unit as the sensor pressure range (kPa or MPa). Barometric pressure is usually recorded in inches of mercury. The conversion factor (F) for inches of mercury to kPa is 3.3863 and from inches of mercury to MPa is 0.003386. Table 2 in Section 5.3.2 lists other common conversion factors.

The user should be cautioned that this correction scheme assumes ideal conditions. Conditions are not always ideal. For example, if the well is sealed, barometric effects at the sensor level may be minimal or attenuated from the actual changes at the surface. Thus, errors may result from applying a correction that is not required. In these cases, GEOKON recommends independently recording the barometric pressure changes and correlating them with the observed pressure changes to arrive at a correction factor.

An alternative to making barometric corrections is to use sensors that are vented to the atmosphere (see Section 5.4). However, vented sensors only make sense if the sensor is in an open well or standpipe and the user is only interested in the water level. If the sensor is buried it is not certain that the full effect of the barometric change will be felt immediately at the instrument and is more likely to be attenuated and delayed, in which case a vented sensor would automatically apply a correction that is too large and too soon.

5.3 OPTIONAL CALCULATIONS

5.3.1 TEMPERATURE CORRECTION

The sensors are thermally compensated over normal temperatures. Temperature correction is not required unless the temperature is changing rapidly. If this occurs, time should be allowed for the transducer to reach thermal equilibrium.

5.3.2 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 2.

		Convert From											
		psi	"H_2O	'H_2O	mm H_2O	m H_2O	"HG	mm HG	atm	mbar	bar	kPa	MPa
Convert To	psi	1	.036127	.43275	.0014223	1.4223	.49116	.019337	14.696	.014503	14.5039	.14503	145.03
	"H_2O	27.730	1	12	.039372	39.372	13.596	.53525	406.78	.40147	401.47	4.0147	4016.1
	'H_2O	2.3108	.08333	1	.003281	3.281	1.133	.044604	33.8983	.033456	33.4558	.3346	334.6
	mm H_2O	704.32	25.399	304.788	1	1000	345.32	13.595	10332	10.197	10197	101.97	101970
	m H_2O	.70432	.025399	.304788	.001	1	.34532	.013595	10.332	.010197	10.197	.10197	101.97
	"HG	2.036	.073552	.882624	.0028959	2.8959	1	.03937	29.920	.029529	29.529	.2953	295.3
	mm HG	51.706	1.8683	22.4196	.073558	73.558	25.4	1	760	.75008	750.08	7.5008	7500.8
	atm	.06805	.002458	.029499	.0000968	.0968	.03342	.001315	1	.000986	.98692	.009869	9.869
	mbar	68.947	2.4908	29.8896	.098068	98.068	33.863	1.3332	1013.2	1	1000	10	10000
	bar	.068947	.002490	.029889	.0000981	.098068	.033863	.001333	1.0132	.001	1	.01	10
	kPa	6.8947	.24908	2.98896	.0098068	9.8068	3.3863	.13332	101.320	.1	100	1	1000
	MPa	.006895	.000249	.002988	.0000098	.009807	.003386	.000133	.101320	.0001	.1	.001	1

TABLE 2: *Engineering Units Conversion Multipliers*

5.4 MODEL 3400SV, VENTED SEMICONDUCTOR PIEZOMETERS

***FIGURE 8:** Vented Semiconductor Piezometers*

The Model 3400SV Vented Semiconductor Piezometer is designed to eliminate the effect of barometric pressure changes on water level measurements in wells, reservoirs, and boreholes that are connected directly to the atmosphere. They are better suited for water level monitoring applications, and typically not intended to be used to monitor pore pressures.

The space inside the sensor is not hermetically sealed and evacuated, as it is in the standard Model 3400 Semiconductor, instead, it is connected via a tube (integral within the cable) to the atmosphere. A chamber containing desiccant capsules is attached to the outer end of this tube to prevent moisture from entering the sensor cavity. A 2.5 ft length of blue cable is spliced at the end of the tubing, this allows for a standard connection to a readout or datalogger as needed. Vented sensors require more maintenance then unvented types, since there is always the danger that moisture may find its way inside the sensor and ruin it.

Installation of the sensor is accomplished by lowering it to the desired level in the well, reservoir, or borehole. The sensor can be placed inside a canvas bag filled with sand, if desired.

The desiccant capsule chamber needs to be positioned in some kind of housing to keep it dry. GEOKON can provide suitable housings on request.

To keep the desiccant fresh during storage and transportation, the end of the desiccant chamber is closed off by means of a seal screw before being shipped from the factory. **THIS SEAL SCREW MUST BE REMOVED BEFORE THE SENSOR IS PUT INTO SERVICE.**

The desiccant capsules are blue when fresh. They will gradually turn pink as they absorb moisture. When they have turned light pink in color, they should be replaced. Contact GEOKON for replacement capsules.

5.5 ENVIRONMENTAL FACTORS

Since the purpose of the sensor installation is to monitor site conditions, factors that can affect these conditions should always be observed and recorded. Seemingly minor affects 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, traffic, temperature and barometric changes, weather conditions, changes in personnel, nearby construction activities, excavation and fill level sequences, seasonal changes, etc.

6. TROUBLESHOOTING

Technical Support

Maintenance and troubleshooting of the sensor is confined to periodic checks of cable connections and maintenance of terminals. Once installed, the instrument 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 READINGS ARE UNSTABLE

- ☐ Is there a source of electrical noise nearby? Most probable sources of electrical noise are motors, generators, transformers, arc welders and antennas. Make sure the shield drain wire is connected to ground.
- ☐ Does the readout or datalogger work with another sensor? If not the readout or datalogger may have a low battery or be malfunctioning. Consult the appropriate readout manual for charging or troubleshooting.
- ☐ The sensor may have been damaged by over-ranging or shock. Inspect the diaphragm and housing for damage.

SYMPTOM: SENSOR FAILS TO GIVE A READING

- ☐ Is the cable cut or crushed? This can be checked with an ohmmeter. This can be checked with an ohmmeter. If the resistance reads infinite or very high (megohms), a cut wire must be suspected. If the resistance reads very low (<100Ω), a short in the cable is likely.
- ☐ Does the readout or datalogger work with another sensor? If not the readout or datalogger may have a low battery or be malfunctioning. Consult the appropriate readout manual for charging or troubleshooting.

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 3.6.

SYMPTOM: THERMISTOR RESISTANCE IS TOO LOW

- ☐ Check for an open circuit. Check all connections, terminals, and plugs. If a cut is in the cable, splice according to instructions in Section 3.6.
- ☐ Water may have penetrated the interior of the sensor. There is no remedial action.

APPENDIX A. SPECIFICATIONS

A.1 MODEL 3400 SPECIFICATIONS

Model	3400-1	3400-2	3400-3
Output	0-100 mV (10 mV/V)	0-5 VDC	4-20 mA
Supply Voltage	10 VDC Regulated (2.5 to 12 V)	24 VDC (7-32 VDC)	24 VDC (7-32 VDC)
Pressure Range[1]	Vacuum to 80 bar (875 psi)		
Over Pressure[2]	2 x Full Scale (F.S.)		
Performance			
Long Term Drift	±0.5% F.S./year typical (±0.1% F.S. maximum)		
Accuracy	±0.2% F.S. (other options available)		
Thermal Error	1.5% F.S. typical (optional 1% F.S.)		
Compensated Temperatures	-20° to 80 °C (-4° to 176 °F)		
Operating Temperatures	-55 to +125 °C (-67 to +257 °F) Internal Sensor		
Zero Tolerance	1% F.S. (mV Versions: ±3.0 mV)		
Span Tolerance	1% F.S. (mV Versions: ±3.0 mV)		
Mechanical Configuration			
Pressure Port	7/16-20 UNJF Male 74° External Cone		
Wetted Parts	316L Stainless Steel & Hastelloy C276		
Electrical Connection	see ordering chart		
Vibration	30 g, 10 to 2000 Hz		

TABLE 3: *Model 3400 Semiconductor Piezometer Specifications*

Note:

[1] Other ranges available on request.

[2] Up to 200 bar for ranges ≤70 bar and up to 1200 bar for ranges >70 bar.

A.2 THERMISTOR

See Appendix B for more information.

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:

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

EQUATION 5: *3KΩ Thermistor Resistance*

Where:
T = Temperature in °C
LnR = Natural Log of Thermistor Resistance
A = 1.4051×10^{-3}
B = 2.369×10^{-4}
C = 1.019×10^{-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. WIRING CHARTS

Warning! Incorrect connection may cause permanent and irreparable damage to the sensor.

C.1 0-5 VOLT DIRECT CURRENT OUTPUT SENSORS

Multimeter set to read in Volts (V) DC and power supply set at 24 VDC (7-32 VDC).

GEOKON **Cable #04-375V9 (Violet)**	**Multimeter Connection**	**Power Supply Connection**	**Function/Description**
Red	N/C	Red (+)	Power +
Red's Black	N/C	Black (-)	Power -
White	Red (+)	N/C	Signal +
White's Black	Black (-)	N/C	Signal -
Blue	N/C	N/C	Thermistor
Blue's Black	N/C	N/C	Thermistor
Shield	N/C	N/C	Ground

TABLE 5: *0-5 Volt Direct Current Output Sensors*

C.2 0-100 MILLIVOLT OUTPUT SENSORS

Multimeter set to read in millivolts (mV) DC and power supply set at 10 VDC Regulated (2.5 to 12 V).

GEOKON **Cable #04-375V9 (Violet)**	**Multimeter Connection**	**Power Supply Connection**	**Function/Description**
Red	N/C	Red (+)	Power +
Red's Black	N/C	Black (-)	Power -
White	Red (+)	N/C	Signal +
White's Black	Black (-)	N/C	Signal -
Green	N/C	N/C	Remote Sense + (optional)
Green's Black	N/C	N/C	Remote Sense - (optional)
Blue	N/C	N/C	Thermistor
Blue's Black	N/C	N/C	Thermistor
Shield	N/C	N/C	Ground

TABLE 6: *0-100 Millivolt Output Sensors*

C.3 4-20 MILLIAMP OUTPUT SENSORS

Multimeter set to read in milliamps (mA) DC and power supply set at 24 VDC (7-32 VDC).

Connect the black (-) leads of the multimeter and power supply together.

GEOKON **Cable #02-250V6 (Blue)**	**Multimeter Connection**	**Power Supply Connection**	**Function/Description**
Red	N/C	Red (+)	Power +
Black	Red (+)	N/C	Power -
White	N/C	N/C	Thermistor
Green	N/C	N/C	Thermistor
Shield	N/C	N/C	Ground

TABLE 7: *4-20 Milliamp Output Sensors*

APPENDIX D. TYPICAL CALIBRATION REPORT

GEOKON

Pressure Transducer Calibration Report

This Calibration has been Verified/ Validated as of: March 28, 2024

Model Number: 3400S-1-100 kPa

Date of Calibration: July 24, 2023

Serial Number: 2307155

Temperature: 20.8 °C

Pressure Range: 100 kPa

Technician:

Calibration Instruction: CI-Semiconductor (7 kPa ~ 2.5 MPa)

Applied Pressure (kPa)	Gauge Reading (mV) 1st Cycle	Gauge Reading (mV) 2nd Cycle	Average Gauge Reading	Linearity (%FS)	Polynomial Fit (%FS)
0	0.424	0.424	0.424	-0.07	0.00
20	20.46	20.46	20.46	0.01	-0.01
40	40.48	40.48	40.48	0.07	0.00
60	60.44	60.43	60.44	0.06	0.00
80	80.35	80.35	80.35	0.02	0.00
100	100.21	100.21	100.21	-0.08	0.00

Linear Gauge Factor (G): 1.0021 (kPa / mV) **Regression Zero: 0.497**

Polynomial Gauge Factors: A: 5.87E-05 **B: 0.9962** **C: -0.4177**

Calculated Pressures: Linear, $P = G(R_1 - R_0) \times 10/V_I$

Polynomial, $P = AR_P^2 + BR_P + C$ $[R_P = R_1 \times 10/V_I]$

Input Voltage, V_I: 10 VDC

Wiring Code: See manual for further 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.
This report shall not be reproduced except in full without written permission of Geokon.

FIGURE 9: *Model 3400-1 Typical Calibration Report*

GEOKON

Pressure Transducer Calibration Report

This Calibration has been Verified/ Validated as of: March 30, 2023

Model Number: 3400SV-2-100 kPa

Date of Calibration: February 28, 2023

Serial Number: 2267310

Temperature: 22.4 °C

Pressure Range: 100 kPa

Technician:

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Applied Pressure (kPa)	Gauge Reading (Volts) 1st Cycle	Gauge Reading (Volts) 2nd Cycle	Average Gauge Reading	Linearity (%FS)	Polynomial Fit (%FS)
0	-0.006	-0.006	-0.006	-0.04	0.01
20	0.997	0.997	0.997	0.00	-0.01
40	2.001	2.000	2.001	0.04	0.00
60	3.002	3.001	3.002	0.03	0.00
80	4.003	4.002	4.003	0.02	0.01
100	5.001	5.000	5.001	-0.05	-0.01

Linear Gauge Factor (G): **19.97** **(kPa / Volt)** **Regression Zero:** **-0.0042**

Polynomial Gauge Factors: A: **1.24E-02** **B:** **19.91** **C:** **0.126**

Calculated Pressures: **Linear,** $P = G(R_1 - R_0)$

Polynomial, $P = AR_1^2 + BR_1 + C$

Input Voltage: 24 VDC

Wiring Code: See manual for further 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.

This report shall not be reproduced except in full without written permission of Geokon.

FIGURE 10: *Model 3400-2 Typical Calibration Report*

GEOKON

Pressure Transducer Calibration Report

This Calibration has been Verified/ Validated as of: August 13, 2021

Model Number: 3400-3-2.5 MPa

Date of Calibration: August 12, 2021

Serial Number: 2141272

Temperature: 21.8 °C

Pressure Range: 2.5 MPa

Technician:

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Applied Pressure (MPa)	Gauge Reading (mA) 1st Cycle	Gauge Reading (mA) 2nd Cycle	Average Gauge Reading	Change	Linearity (%FS)	Polynomial Fit (%FS)
0.0	3.989	3.989	3.989		-0.04	0.00
0.5	7.197	7.197	7.197	3.21	0.00	-0.01
1.0	10.403	10.403	10.403	3.21	0.04	0.00
1.5	13.603	13.603	13.603	3.20	0.04	0.00
2.0	16.799	16.799	16.799	3.20	0.01	0.00
2.5	19.990	19.990	19.990	3.19	-0.05	0.00

Linear Gauge Factor (G): 0.1562 (MPa/ mA) **Regression Zero: 3.996**

Polynomial Gauge Factors: A: 3.41E-05 **B: 0.1554** **C: -0.6204**

Calculated Pressures: Linear, $P = G(R_1 - R_0)$

Polynomial, $P = AR_1^2 + BR_1 + C$

Input Voltage: 24 VDC

Wiring Code: See manual for further 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.

***FIGURE 11:** Model 3400-3 Typical Calibration Report*

GEOKON
48 Spencer Street
Lebanon, New Hampshire
03766, USA

Phone: +1 (603) 448-1562
Email: info@geokon.com
Website: www.geokon.com

GEOKON
is an **ISO 9001:2015**
registered company