

*Instruction Manual*

# Model 46750C

## Liquid Level Sensor

No part of this instruction manual may be reproduced, by any means, without the written consent of Geokon, Inc.

The information contained herein is believed to be accurate and reliable. However, Geokon, Inc. assumes no responsibility for errors, omissions or misinterpretation. The information herein is subject to change without notification.

Copyright © 1995, 2006, 2008 by Geokon, Inc.

(Doc Rev F, 06/08)



## Warranty Statement

Geokon, Inc. warrants its products to be free of defects in materials and workmanship, under normal use and service for a period of 13 months from date of purchase. If the unit should malfunction, it must be returned to the factory for evaluation, freight prepaid. Upon examination by Geokon, if the unit is found to be defective, it will be repaired or replaced at no charge. However, the WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive corrosion or current, heat, moisture or vibration, improper specification, misapplication, misuse or other operating conditions outside of Geokon's control. Components which wear or which are damaged by misuse are not warranted. This includes fuses and batteries.

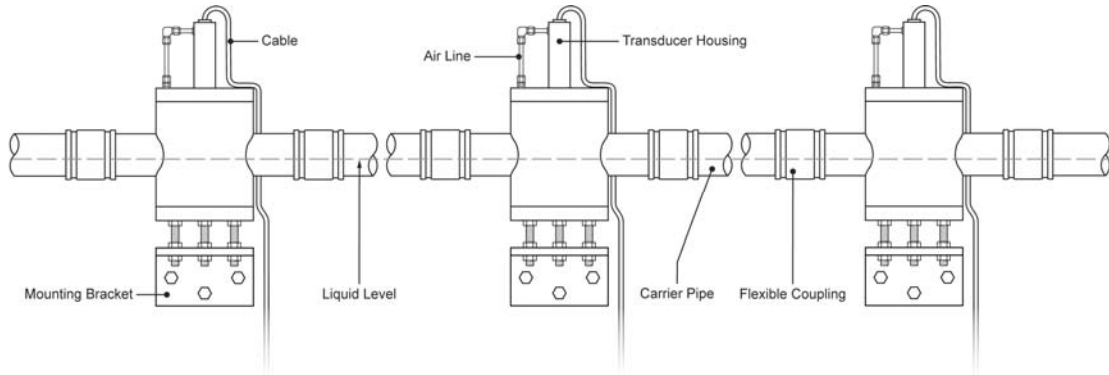
Geokon manufactures scientific instruments whose misuse is potentially dangerous. The instruments are intended to be installed and used only by qualified personnel. There are no warranties except as stated herein. There are no other warranties, expressed or implied, including but not limited to the implied warranties of merchantability and of fitness for a particular purpose. Geokon, Inc. 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, Inc. or any breach of any warranty by Geokon, Inc. shall not exceed the purchase price paid by the purchaser to Geokon, Inc. 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, Inc. 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

<b>1. INTRODUCTION AND THEORY OF OPERATION.....</b>	<b>1</b>
---	----------



.....	2
-------	---

<b>2. INSTALLATION .....</b>	<b>2</b>
------------------------------	----------

2.1 INSTALL THE MOUNTING BRACKETS .....	2
2.2 INSTALLING THE SENSORS .....	2
2.3 INSTALLING THE CARRIER PIPE .....	2
2.4 FILLING THE CARRIER PIPE .....	3

<b>3. CALIBRATION .....</b>	<b>4</b>
-----------------------------	----------

<b>4. TAKING READINGS.....</b>	<b>4</b>
--------------------------------	----------

<b>5. CORRECTIONS FOR TEMPERATURE CHANGES .....</b>	<b>5</b>
---	----------

<b>6. TROUBLESHOOTING.....</b>	<b>7</b>
--------------------------------	----------

<b>7. SPECIFICATIONS.....</b>	<b>7</b>
-------------------------------	----------

<b>APPENDIX A: THERMISTOR CHART .....</b>	<b>8</b>
---	----------

<b>APPENDIX B: TYPICAL CALIBRATION SHEET.....</b>	<b>9</b>
---	----------

## Vibrating Wire Liquid Level Sensor Calibration Report

Model Number: 4675OC Temperature: 24.1 °C  
 Serial Number: 1141486 Calibration Date: December 29, 2011  
 Calibration Instruction: CI-4675 Technician: \_\_\_\_\_

Applied Load L (lbs)	Equivalent inches H <sub>2</sub> O	Reading 1st Cycle	Reading 2nd Cycle	Average Reading (R)	Change	Linearity (%FS)	Polynomial Fit % (FS)
1.430	3.158	6544	6546	6545			
1.760	3.887	7824	7829	7827	1282	0.19	0.01
2.090	4.617	9105	9102	9104	1277	0.22	-0.02
2.422	5.349	10379	10380	10380	1276	0.20	0.02
2.752	6.078	11644	11640	11642	1263	0.01	-0.01

Factory reading with the cylindrical weight hanging in air = 10849  
 Mid-range reading = 8231  
 Equivalent inches of H<sub>2</sub>O = L x K

Weight

Cylinder Dimensions (inches): Range: 3 inches

	1	2	3	
Top	3.996	3.994	3.995	Manufacturing Number: <u>HW-11-172</u>
Middle	3.993	3.995	3.997	Average Diameter (D): <u>3.995</u>
Bottom	3.996	3.994	3.999	Volume Factor (K): <u>2.209</u> (inches / lb)

$K = 1/(0.02836 \times D^2)$

**Calibration Factor (G):** 0.000573 (inches / digit) or 0.01455 (mm / digit)  
 Change in Sensor Elevation =  $G(R_1 - R_0)$

**Polynomial Gage Factors:**    **A:** 1.0754E-09                      **B:** 0.0005533                      **C:** -0.5096  
 Polynomial,  $P = AR_1^2 + BR_1 + C$

Wiring Code:                      Red and Black: Gage                      White and Green: Thermistor

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 Inc.

**LIST of FIGURES, TABLES and EQUATIONS**

FIGURE 1. MODEL 4675OC LIQUID LEVEL SENSOR – STANDARD SYSTEM..... 1  
 FIGURE 2. MODEL 4675OC LIQUID LEVEL SENSOR – IN-LINE SYSTEM..... 2

FIGURE 3. DENSITY $\rho$ OF PURE WATER AS A FUNCTION OF TEMPERATURE AND PRESSURE INTENSITY .....	6
THERMISTOR LINEARIZATION USING STEINHART AND HART LOG EQUATION.....	8
RESISTANCE VERSUS TEMPERATURE TABLE .....	8



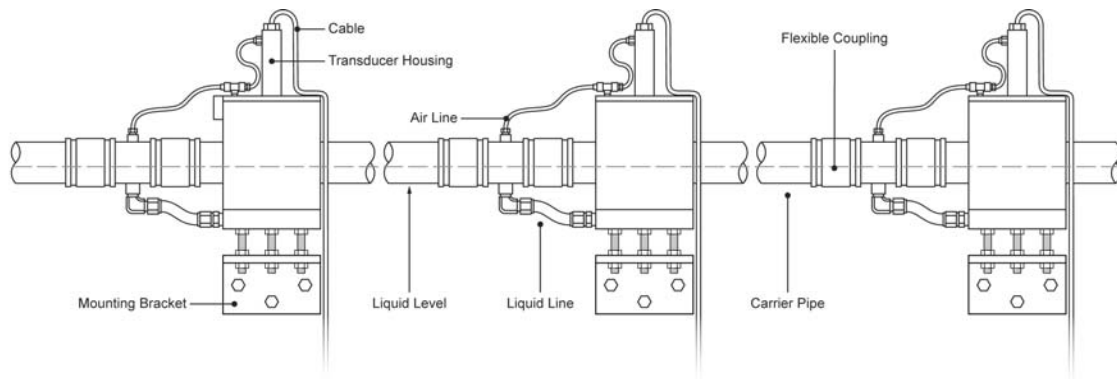
## 1. Introduction and Theory of Operation

The Model 4675OC System is designed to detect and measure very small changes of elevation at discrete locations. It has been used to measure differential settlements along tunnels, deflections of bridges and bridge piers, the settlement of building columns and floor slabs etc., i.e. situations in which high accuracy and resolution are essential.

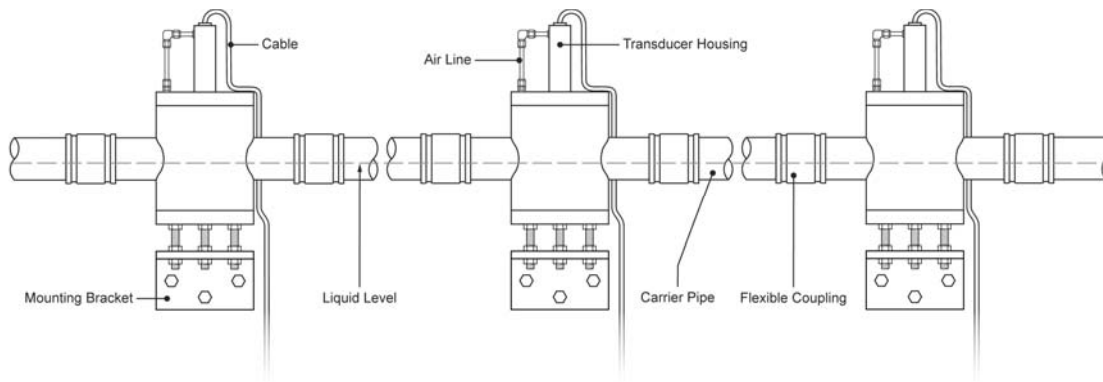
A series of chambers, (vessels), are connected together by means of pipe that is installed on a level plane and is half-filled with liquid. One reference chamber is located on stable ground or is at a point that can be surveyed to. The other chambers are located at the points where settlement or heave is to be measured. Each chamber contains a cylindrical weight suspended from a vibrating wire transducer. The common liquid level inside each chamber partially submerges the hanging weights so that settlement or heave of at any one of the chamber locations causes an apparent rise or fall of the water level in that chamber, leading to a greater or lesser buoyancy force on the weight and an decrease or increase of tension and frequency of vibration in the vibrating wire.

A very high resolution/accuracy of the order of 0.02mm can be attained. A vent line connects each transducer element to the air space above the liquid in each of the chambers and the carrier pipe and reduces the effect on the readings caused by changing temperatures and barometric fluctuations. It will be noted that the vibrating wire transducer is measuring a force and thus is itself not subject to temperature effects. Temperature effects on the connecting pipe and the liquid result in equal changes in water level in all the chambers and thus is cancelled out when the data is reduced.

Readout of the instruments is accomplished with portable readouts such as the GK-403 or the GK-404 or one of the Geokon data acquisition systems such as the Micro-1000.



*Figure 1. Model 4675OC Liquid Level Sensor – Standard System*



*Figure 2. Model 4675OC Liquid Level Sensor – In-Line System*

## 2. Installation

Before any attempt is made to install the sensors the following directions must be read and understood.

The vibrating wire transducer is very sensitive and correspondingly fragile, and must be handled with great care.

### 2.1 Install the mounting brackets

The first step is to install the mounting brackets. It is important to install all chambers at the same elevation at the start of the monitoring program since the range of the transducer is limited and the amount of adjustment is small.

The chamber mounting bracket is designed to be bolted to a wall or a pedestal and should be firmly attached with either anchor bolts or epoxy grouted studs. The bracket can be attached to curved surfaces such as pillars by adding shims between the bracket and the surface to which it is bolted.

### 2.2 Installing the sensors

After the mounting brackets have been installed the gages can be mounted. The mounting bracket has three holes positioned to accept the threaded rods on the base of the liquid level chamber. These threaded rods are used to level the chamber on the bracket and allow a small amount of vertical positioning. Attach 3 of the jam nuts provided to the threaded rods and position them about 1" above the end of the rod. Now place the chamber on the bracket with the rods through the holes in the bracket and attach nuts to the rods on the lower side of the bracket. Using a spirit level on the side of the chamber, level the chamber assembly with the leveling nuts and then lock into place.

### 2.3 Installing the Carrier Pipe

The next step is to install the carrier pipe. This is usually accomplished by running a 3 or 4" diameter pipe, suspended from pipe brackets and connected together with flexible couplers between chambers, with special couplings located at the chamber positions allowing the connection of the liquid and air lines to the sensor. The interconnecting pipe must be kept at a precise elevation to ensure that the transducer is at the midpoint in its range when the measurements commence. The centerline of the pipe should coincide with the midpoint of the sensors range which is indicated on the chamber housing.

Note: The In-line, through-the chamber, model has the carrier pipe mounted on the chamber itself and this system must be installed in a serial fashion to allow for connecting the pipe and sensors.

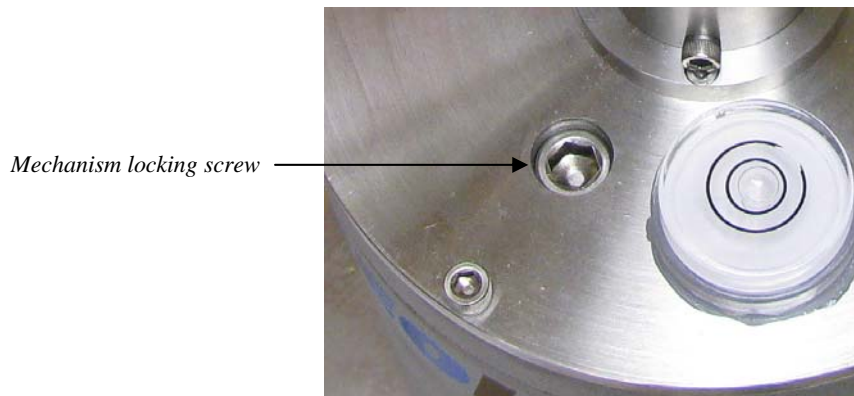
#### 2.4 Filling the Carrier pipe

Calculate the volume of liquid required to fill the total length of the carrier to the halfway point on the pipe, plus 21 cubic inches or 0.75 lbs. per sensor. The liquid normally used for filling the carrier is distilled water and if the area of measurements is expected to see freezing conditions a solution with a precisely know anti-freeze content is used. The amount of antifreeze should be kept to the minimum that will prevent freezing.

Connect the supply to the end of the carrier pipe and allow the liquid to flow into the pipe slowly.

Note: For the standard system where the sensor is connected to the carrier by a tube the liquid line should be connected to the carrier but not connected to the sensor at this time. Secure the end of this tube such that is above the carrier pipe. For the through system the stainless steel tube from the chamber to the transducer must be disconnected at the chamber end during this filling operation.

The sensors can be monitored during the filling operation to determine the level of the liquid in the pipe and the chambers. In order to do this the locking mechanism must be released so the buoyancy cylinder hangs freely in the chamber. Note that the locking mechanism **MUST BE ENGAGED** whenever the sensor assembly is moved or transported. To release the buoyancy cylinder use the 5/16" Allen hex wrench provided. Engage and rotate the recessed cap screw counterclockwise until it hits the stop and the resistance to turning goes up markedly. The sensor can now be read and the water level checked electronically.



After filling, the sensor operation should be confirmed now by taking readings on all sensors and calculating the submersion of each sensor. This is accomplished by taking the change in output of the gage from the zero reading, (R0) with the weight hanging in air, and the current reading with the weight submerged and multiplying by the gage factor. The gage factor and zero reading, (R0) are shown on the calibration sheets. (See Appendix B, Page 10). The result should match the expected position of the water in the carrier pipe.

### 3. Calibration

Laboratory calibrations are performed on each individual sensor using a system of calibrated weights. Gage factors are presented for pure water applications. If mixtures other than this are used, the gage factor should be adjusted for the specific gravity of the fluid used.

### 4. Taking Readings

The Model 4675 is read using the GK-401, GK-403 or GK-404 Readout Box in Position 'B'.

The change in elevation for any particular chamber in a system is determined as follows:

$$\Delta EL_x = (R_{1_x} - R_{0_x}) G_x - (R_{1_{Ref}} - R_{0_{Ref}}) G_{Ref}$$

where:

$\Delta EL_x$  = Change in Elevation for Chamber x

$R_{1_x}$  = Current Reading Chamber x

$R_{0_x}$  = Initial Reading Chamber x

$G_x$  = Calibration Factor Chamber x

$R_{0_{Ref}}$  = Initial Reading Reference Chamber

$R_{1_{Ref}}$  = Current Reading Reference Chamber

$G_{Ref}$  = Calibration Factor Reference Chamber

Note: Negative values of  $\Delta EL_x$  indicate settlement. (Positive values of  $\Delta EL_x$  indicated heave).

Example: The initial readings on a 4 chamber system (3 active and reference chamber) are as follows:

Chamber	Reading	Calibration Factor
1 (Ref)	7163	0.002852
2	7858	0.002856
3	7967	0.002808
4	8028	0.002852

Subsequent readings on the chambers are as follows:

Chamber	Reading
1 (Ref)	7118
2	7813
3	8628
4	7637

The changes in elevation of Chambers 2, 3 and 4 are:

$$\begin{aligned}
 \text{a) Chamber No. 2: } \Delta EL_2 &= (\mathbf{R}_{1_2} - \mathbf{R}_{0_2}) \mathbf{G}_2 - (\mathbf{R}_{1_1} - \mathbf{R}_{0_1}) \mathbf{G}_1 \\
 &= (7813 - 7858) 0.002856 - (7118 - 7163) 0.002852 \\
 &= -0.1285 - (-0.1283) \\
 &= -0.0002'' \quad (\text{No Movement})
 \end{aligned}$$

$$\begin{aligned}
 \text{b) Chamber No. 3: } \Delta EL_3 &= (\mathbf{R}_{1_3} - \mathbf{R}_{0_3}) \mathbf{G}_3 - (\mathbf{R}_{1_1} - \mathbf{R}_{0_1}) \mathbf{G}_1 \\
 &= (8628 - 7967) 0.002808 - (7118 - 7163) 0.002852 \\
 &= 1.8561 - (-0.1283) \\
 &= 1.9843'' \quad (\text{Heave})
 \end{aligned}$$

$$\begin{aligned}
 \text{c) Chamber No. 4: } \Delta EL_4 &= (\mathbf{R}_{1_4} - \mathbf{R}_{0_4}) \mathbf{G}_4 - (\mathbf{R}_{1_1} - \mathbf{R}_{0_1}) \mathbf{G}_1 \\
 &= (7637 - 8028) 0.002852 - (7118 - 7163) 0.002852 \\
 &= -1.1151 - (-0.1283) \\
 &= -0.9868'' \quad (\text{Settlement})
 \end{aligned}$$

## 5. Corrections for Temperature Changes

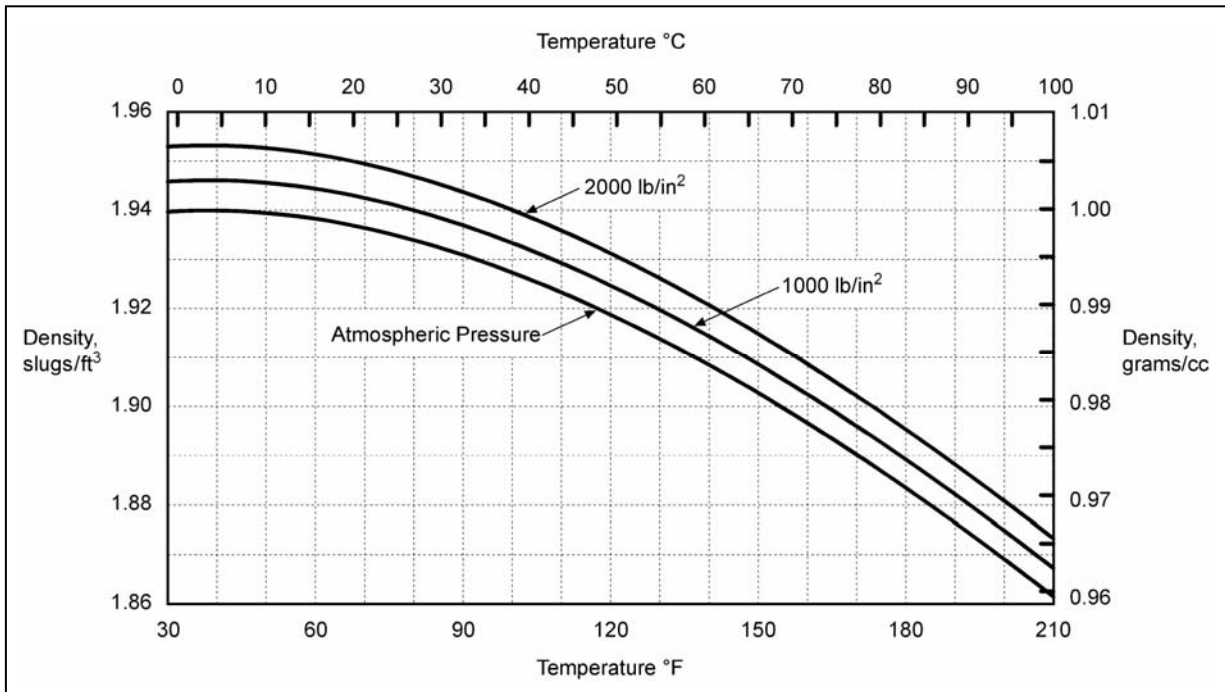
The vibrating wire sensor itself is insensitive to temperature changes within the normal operating range. The system, however, is not entirely unaffected by changes in water temperature which influence the density and therefore, the buoyancy of the fluid. The influence is relatively minor and can be accounted for to some degree by measuring the water temperature and making density corrections. A temperature/density curve for water is shown in Figure 2. As can be seen from the data, the density changes very little in the normal operating range of the sensor. The following equation is used to correct for temperature/density changes:

$$\Delta H = (\mathbf{R}_1 - \mathbf{R}_0) \mathbf{G} / (\mathbf{SG})$$

where: SG is the specific gravity of the fluid (water) at the measurement temperature

Density and Compressibility

Density is defined as the mass per unit volume, and it depends upon the temperature and pressure intensity. The density of pure water is given in Figure 3.



*Figure 3. Density  $\rho$  of pure water as a function of temperature and pressure intensity. By permission from *Fluid Mechanics for Hydraulic Engineers*, by Hunter Rouse, copyright 1938, McGraw-Hill Book Company, Inc.*

Expansion and contraction of the liquid line, the liquid itself and the chambers can cause the water level to fluctuate. However, the fluctuations are the same at all chambers and cancel out on data reduction.

## 6. Troubleshooting

If a transducer fails to read, the following steps should be taken

1. Check the coil resistance. Nominal coil resistance is  $180\Omega \pm 10$  plus cable resistance (22 gage copper = approximately  $20\Omega$  per 1000 feet).
  - a) If the resistance is high or infinite, a cut cable must be suspected.
  - b) If the resistance is low or near zero, a short must be suspected.
  - c) If resistances are within nominal and no readings are obtainable on any transducer, the readout is suspect and the factory should be consulted.
  - d) If all resistances are within nominal and no readings are obtainable on any transducer, the readout is suspect and the factory should be consulted.
2. If cuts or shorts are located, the cable may be splices in accordance with recommended procedures.

## 7. Specifications

Standard range	75mm	
Resolution	0.025mm	
System accuracy	$\pm 0.1$ to $\pm 0.4$ mm	
Temperature Range	$-20^{\circ}\text{C}$ to $+80^{\circ}\text{C}$	
Frequency Range	1400-3500Hz	

## Appendix A: Thermistor Chart

### *Thermistor Linearization using Steinhart and Hart Log Equation*

Tech Memo 91-03 Doc Rev 6-94, Geokon, Inc.

**Thermistor Type: YSI 44005, Dale #1C3001-B3, Alpha #13A3001-B3**

**Basic Equation:** 
$$T = \frac{1}{A + B(\text{LnR}) + C(\text{LnR})^3} - 273.2$$

where:

**T** = Temperature in °C.

**LnR** = Natural Log of Thermistor Resistance

$$A = 1.4051 \times 10^{-3}$$

$$B = 2.369 \times 10^{-4}$$

$$C = 1.019 \times 10^{-7}$$

*Note: Coefficients calculated over -50° to +150° C. span.*

*Resistance versus Temperature Table*

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	16.60K	-10	2417	+30	525.4	+70	153.2	+110
187.3K	-49	15.72K	-9	2317	31	507.8	71	149.0	111
174.5K	-48	14.90K	-8	2221	32	490.9	72	145.0	112
162.7K	-47	14.12K	-7	2130	33	474.7	73	141.1	113
151.7K	-46	13.39K	-6	2042	34	459.0	74	137.2	114
141.6K	-45	12.70K	-5	1959	35	444.0	75	133.6	115
132.2K	-44	12.05K	-4	1880	36	429.5	76	130.0	116
123.5K	-43	11.44K	-3	1805	37	415.6	77	126.5	117
115.4K	-42	10.86K	-2	1733	38	402.2	78	123.2	118
107.9K	-41	10.31K	-1	1664	39	389.3	79	119.9	119
101.0K	-40	9796	0	1598	40	376.9	80	116.8	120
94.48K	-39	9310	+1	1535	41	364.9	81	113.8	121
88.46K	-38	8851	2	1475	42	353.4	82	110.8	122
82.87K	-37	8417	3	1418	43	342.2	83	107.9	123
77.66K	-36	8006	4	1363	44	331.5	84	105.2	124
72.81K	-35	7618	5	1310	45	321.2	85	102.5	125
68.30K	-34	7252	6	1260	46	311.3	86	99.9	126
64.09K	-33	6905	7	1212	47	301.7	87	97.3	127
60.17K	-32	6576	8	1167	48	292.4	88	94.9	128
56.51K	-31	6265	9	1123	49	283.5	89	92.5	129
53.10K	-30	5971	10	1081	50	274.9	90	90.2	130
49.91K	-29	5692	11	1040	51	266.6	91	87.9	131
46.94K	-28	5427	12	1002	52	258.6	92	85.7	132
44.16K	-27	5177	13	965.0	53	250.9	93	83.6	133
41.56K	-26	4939	14	929.6	54	243.4	94	81.6	134
39.13K	-25	4714	15	895.8	55	236.2	95	79.6	135
36.86K	-24	4500	16	863.3	56	229.3	96	77.6	136
34.73K	-23	4297	17	832.2	57	222.6	97	75.8	137
32.74K	-22	4105	18	802.3	58	216.1	98	73.9	138
30.87K	-21	3922	19	773.7	59	209.8	99	72.2	139
29.13K	-20	3748	20	746.3	60	203.8	100	70.4	140
27.49K	-19	3583	21	719.9	61	197.9	101	68.8	141
25.95K	-18	3426	22	694.7	62	192.2	102	67.1	142
24.51K	-17	3277	23	670.4	63	186.8	103	65.5	143
23.16K	-16	3135	24	647.1	64	181.5	104	64.0	144
21.89K	-15	<b>3000</b>	<b>25</b>	624.7	65	176.4	105	62.5	145
20.70K	-14	2872	26	603.3	66	171.4	106	61.1	146
19.58K	-13	2750	27	582.6	67	166.7	107	59.6	147
18.52K	-12	2633	28	562.8	68	162.0	108	58.3	148
17.53K	-11	2523	29	543.7	69	157.6	109	56.8	149
								55.6	150

## Appendix B: Typical Calibration Sheet

Applied Load L (lbs)	Equivalent inches H <sub>2</sub> O	Reading 1st Cycle	Reading 2nd Cycle	Average Reading (R)	Change	Linearity (%FS)	Polynomial Fit % (FS)
1.430	3.158	6544	6546	6545			
1.760	3.887	7824	7829	7827	1282	0.19	0.01
2.090	4.617	9105	9102	9104	1277	0.22	-0.02
2.422	5.349	10379	10380	10380	1276	0.20	0.02
2.752	6.078	11644	11640	11642	1263	0.01	-0.01

Model Number: 4675OC Temperature: 24.1 °C  
 Serial Number: 1141486 Calibration Date: December 29, 2011  
 Calibration Instruction: CI-4675 Technician: \_\_\_\_\_

Factory reading with the cylindrical weight hanging in air = 10849  
 Mid-range reading = 8231  
 Equivalent inches of H<sub>2</sub>O = L x K

**Weight**

Cylinder Dimensions (inches): Range: 3 inches

	1	2	3
Top	3.996	3.994	3.995
Middle	3.993	3.995	3.997
Bottom	3.996	3.994	3.999

Manufacturing Number: HW-11-172  
 Average Diameter (D): 3.995  
 Volume Factor (K): 2.209 (inches / lb)

$K = 1/(0.02836 \times D^2)$

Calibration Factor (G): 0.000573 (inches / digit) or 0.01455 (mm / digit)  
 Change in Sensor Elevation = G(R<sub>1</sub>-R<sub>0</sub>)

Polynomial Gage Factors: A: 1.0754E-09 B: 0.0005533 C: -0.5096  
 Polynomial, P = AR<sub>1</sub><sup>2</sup> + BR<sub>1</sub> + C

Wiring Code: Red and Black: Gage White and Green: Thermistor

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 Inc.