GEOKON®

48 Spencer Street
Lebanon, NH 03766, USA
Tel: 603·448·1562
Fax: 603·448·3216
Email: geokon@geokon.com
http://www.geokon.com

Instruction Manual

Model 4700

VW Temperature Gauge

(Doc Rev J, 05/01/19)

Warranty Statement

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

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

FIGURES

TABLES

EQUATIONS

1. THEORY OF OPERATION

A tensioned steel wire is clamped axially inside a cylindrically shaped, stainless steel body and is made to vibrate at its fundamental frequency by means of electrical pulses fed from a readout, through ac cable, to an electronic coil and permanent magnet assembly mounted close to the wire. Temperature changes cause the stainless steel body to expand and contract at a different rate than the vibration wire. This causes a corresponding change in the wire tension and in its vibrational frequency. Vibration of the wire in the permanent magnetic field induces an alternating current in the electronic coil with the same frequency. The readout used to pluck the wire is mow used to measure this frequency, which can then be related to the temperature by means of a calibration factor supplied with each gauge.

All components are made from stainless steel for corrosion protection. The gauges are waterproof and contain internal protection against lightning damage. Each gauge also incorporates a thermistor for use as a backup or as an independent check on the temperature reading.

The thermal response of the Model 4700 is quite slow; it is not suitable for the measurement of rapidly changing temperatures. (See Appendix A for details.)

2. INSTALLATION

The Model 4700 Vibrating Wire Temperature Sensor are fully waterproof and can be installed inside boreholes, buried in fill, or cast inside concrete with no particular requirements needed.

Preliminary readings should be taken to ensure that the sensor is functioning properly. Most models incorporate a thermistor that can be used as a check on the vibrating wire readout.

3. READOUT PROCEDURES

Connect the black and red leads to the GK-403, GK-404 or GK-405 VW Readout Box and read on channel B. If the GK-403, GK 404 or GK-405 Readout Box or 8600 Datalogger is used, the thermistor readout can be displayed directly in °C.

The thermistor can be read on the green and white conductors using a digital ohmmeter in conjunction with the conversion Table 2 in Appendix C. For High Temperature models, use Table 3 in Appendix D. (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 14.7 ohms per one thousand feet. Multiply this factor by two to account for both directions.)

4. DATA REDUCTION

The temperature (**T**) is given by the formula:

$$T = G\,(R_1 - R_0) \text{ in degrees Centigrade}$$

Equation 1 - Temperature

Where;
R_0 is the initial reading on channel B at 0 °C (from the calibration sheet).
R_1 is the subsequent reading on channel B
G is the gauge factor found on the calibration sheet. (A typical calibration sheet is shown in Appendix B.)

For greater accuracy, use the polynomial equation found on the calibration sheet provided with the instrument.

5. TROUBLE SHOOTING

Maintenance and troubleshooting of vibrating wire temperature sensors are confined to periodic checks of cable connections and maintenance of terminals. The transducers themselves are sealed and cannot be opened for inspection.

Normal resistance between black and red conduction is 180Ω (±5Ω), plus cable resistance of 14.7Ω per 1000 ft. (48.5Ω per km). (Multiply this factor by two to account for both directions.)

Normal resistance between white and green conduction depends on the temperature. (See Table 2 in Appendix C. For High Temperature models, use Table 3 in Appendix D.). If the resistance deviates from the norms, inspect the cable for damage.

APPENDIX A. SPECIFICATIONS

	4700	4700HT
Standard Range	–20 °C to +80 °C	–40 °C to +250 °C[1]
Resolution	0.034 °C (Approximate)	
Accuracy[2]	±0.5°C	
Response Time[3]	2.5 minutes	
Thermal Equilibrium[4]	15 minutes	
Frequency Range	1400 – 3500 Hz	
Diameter	.75" (19.05 mm)	
Length	5.125" (130.175 mm)	
Weight	115 gm	
Cable	Four conductor, shielded, 22 AWG	Optional – Teflon Jacketed (200°C max rating) OR 316SS encapsulated (300°C max rating)

Table 1 - Specifications

Notes:

[1] Maximum temperature is cable dependent

[2] Established under laboratory conditions.

[3] Time required to reach 63.2% of an instantaneous temperature change.

[4] Maximum time required to reach thermal equilibrium.

APPENDIX B. TYPICAL CALIBRATION SHEET

GEOKON 48 Spencer Street, Lebanon, New Hampshire 03766 U.S.A.

Vibrating Wire Temperature Gage Calibration Report

Model Number: 4700

Date of Calibration: March 19, 2012

Serial Number: 1227872

Calibration Instruction: CI-4700

Technician:

Temperature (°C)	Gage Reading	Calculated Temperature (°C)	Linearity (%FS)	Polynomial Fit (%FS)
-20.20	3925.5	-20.62	-0.43	0.00
4.45	4690.8	4.66	0.21	-0.01
28.94	5439.5	29.38	0.45	0.04
53.43	6172.2	53.58	0.16	-0.04
77.75	6891.7	77.35	-0.41	0.01

Linear Gage Factor (G): 0.03303 (°C/ digit)

Reference Reading at 0 °C (R_0): 4549.8 (Regression Zero)

Polynomial Gage Factors: A: 3.761E-07 B: 0.02896 C: -139.67

Calculated Temperature: Linear, $T = G(R_1-R_0)$ Polynomial, $T = AR_1^2 + BR_1 + C$

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

Calibration results: above instrument is found to be within 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 1 - Typical Calibration Sheet

APPENDIX C. THERMISTOR TEMPERATURE DERIVATION

Thermistor Type: YSI 44005, Dale #1C3001-B3, Alpha #13A3001-B3
Resistance to Temperature Equation:

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

Equation 2 - Resistance to Temperature

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 the −50 to +150° C. span.

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	**3000**	**25**	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

Table 2 - Thermistor Resistance versus Temperature

APPENDIX D. HIGH TEMPERATURE THERMISTOR LINEARIZATION

Resistance to Temperature Equation for *US Sensor 103JL1A*:

$$T=\frac{1}{A+B(LnR)+C(LnR)^3+D(LnR)^5}-273.15\ °C$$

Equation 3 - High Temperature Resistance to Temperature

Where;

T = Temperature in °C.

LnR = Natural Log of Thermistor Resistance.

$A = 1.127670 \times 10^{-3}$

$B = 2.344442 \times 10^{-4}$

$C = 8.476921 \times 10^{-8}$

$D = 1.175122 \times 10^{-11}$

Note: Coefficients optimized for a curve "J" Thermistor over the temperature range of 0°C to +250°C.

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
32,650	0	7,402	32	2,157	64	763.5	96	316.6	128	148.4	160	76.5	192	42.8	224
31,029	1	7,098	33	2,083	65	741.2	97	308.7	129	145.1	161	75.0	193	42.1	225
29,498	2	6,808	34	2,011	66	719.6	98	301.0	130	142.0	162	73.6	194	41.4	226
28,052	3	6,531	35	1,942	67	698.7	99	293.5	131	138.9	163	72.2	195	40.7	227
26,685	4	6,267	36	1,876	68	678.6	100	286.3	132	135.9	164	70.8	196	40.0	228
25,392	5	6,015	37	1,813	69	659.1	101	279.2	133	133.0	165	69.5	197	39.3	229
24,170	6	5,775	38	1,752	70	640.3	102	272.4	134	130.1	166	68.2	198	38.7	230
23,013	7	5,545	39	1,693	71	622.2	103	265.8	135	127.3	167	66.9	199	38.0	231
21,918	8	5,326	40	1,637	72	604.6	104	259.3	136	124.6	168	65.7	200	37.4	232
20,882	9	5,117	41	1,582	73	587.6	105	253.1	137	122.0	169	64.4	201	36.8	233
19,901	10	4,917	42	1,530	74	571.2	106	247.0	138	119.4	170	63.3	202	36.2	234
18,971	11	4,725	43	1,480	75	555.3	107	241.1	139	116.9	171	62.1	203	35.6	235
18,090	12	4,543	44	1,432	76	539.9	108	235.3	140	114.5	172	61.0	204	35.1	236
17,255	13	4,368	45	1,385	77	525.0	109	229.7	141	112.1	173	59.9	205	34.5	237
16,463	14	4,201	46	1,340	78	510.6	110	224.3	142	109.8	174	58.8	206	33.9	238
15,712	15	4,041	47	1,297	79	496.7	111	219.0	143	107.5	175	57.7	207	33.4	239
14,999	16	3,888	48	1,255	80	483.2	112	213.9	144	105.3	176	56.7	208	32.9	240
14,323	17	3,742	49	1,215	81	470.1	113	208.9	145	103.2	177	55.7	209	32.3	241
13,681	18	3,602	50	1,177	82	457.5	114	204.1	146	101.1	178	54.7	210	31.8	242
13,072	19	3,468	51	1,140	83	445.3	115	199.4	147	99.0	179	53.7	211	31.3	243
12,493	20	3,340	52	1,104	84	433.4	116	194.8	148	97.0	180	52.7	212	30.8	244
11,942	21	3,217	53	1,070	85	421.9	117	190.3	149	95.1	181	51.8	213	30.4	245
11,419	22	3,099	54	1,037	86	410.8	118	186.1	150	93.2	182	50.9	214	29.9	246
10,922	23	2,986	55	1,005	87	400.0	119	181.9	151	91.3	183	50.0	215	29.4	247
10,450	24	2,878	56	973.8	88	389.6	120	177.7	152	89.5	184	49.1	216	29.0	248
10,000	**25**	2,774	57	944.1	89	379.4	121	173.7	153	87.7	185	48.3	217	28.5	249
9,572	26	2,675	58	915.5	90	369.6	122	169.8	154	86.0	186	47.4	218	28.1	250
9,165	27	2,579	59	887.8	91	360.1	123	166.0	155	84.3	187	46.6	219		
8,777	28	2,488	60	861.2	92	350.9	124	162.3	156	82.7	188	45.8	220		
8,408	29	2,400	61	835.4	93	341.9	125	158.6	157	81.1	189	45.0	221		
8,057	30	2,316	62	810.6	94	333.2	126	155.1	158	79.5	190	44.3	222		
7,722	31	2,235	63	786.6	95	324.8	127	151.7	159	78.0	191	43.5	223		

Table 3 - Thermistor Resistance versus Temperature for High Temperature Models