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Instruction Manual

Model 3900

Embedment Strain Gauge
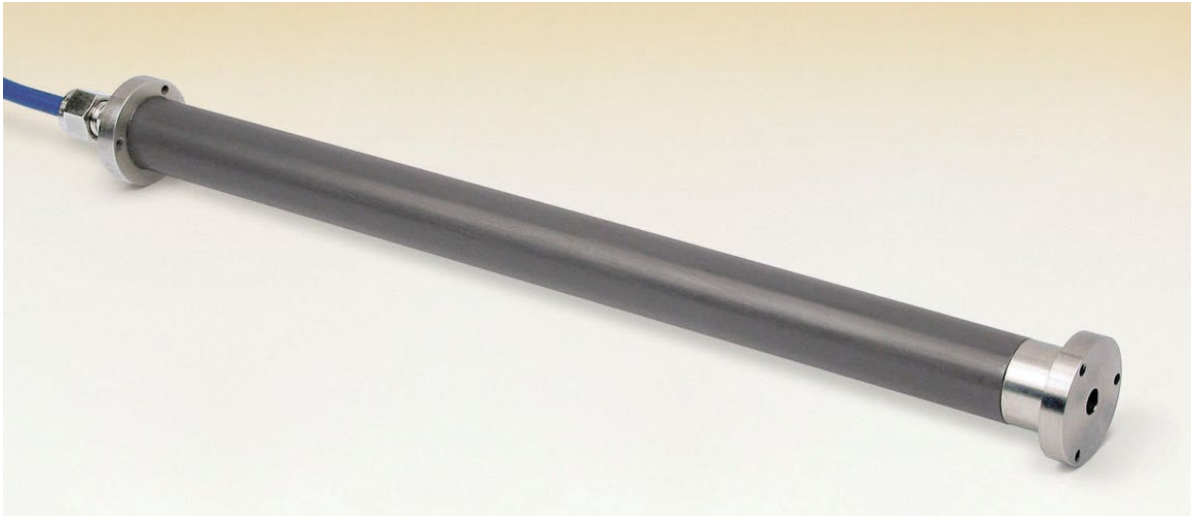
Warranty Statement

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.

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EQUATIONS

1. INTRODUCTION

The Model 3900 Embedment Strain Gauge is designed for the measurement of dynamic strains in concrete structures and soils. It comprises a full-bridge strain gauge proving ring element coupled in series with a tension spring which is stretched between two end flanges. An outer PVC tube sealed with O-rings provides a waterproof housing. The end flanges are embedded and move in accordance with the surrounding material. The voltage signals from the strain gauge are transmitted via cable to the readout location.

The strain gauge can be read out by means of the GEOKON Model 502 Readout Box or by a applying a 2 to 12 Volt excitation to the input leads and reading the corresponding millivolt output. The standard wiring for use with the GK-502 readout box is configured to compensate for the use of long cables by the remote sensing of the input voltage at the sensor. A Thermistor is included inside the sensor to measure temperature. This requires a cable with four shielded pairs of conductors.

2. INSTALLATION

The embedment gauge is delivered with the sensor set at an approximately midrange position ready for installment. The standard range is ± 2500 microstrains. (Other ranges are available). An initial test can be conducted by connecting the strain gauge to the GK-502 Readout Box or to a regulated voltage supply. Movement of the end flanges should produce a corresponding change in the gauge output. At no time should the end flanges be twisted or pulled beyond the range of the sensor as this could permanently damage the gauge.

The gauge should be installed directly in the concrete or soil by hand. Large aggregate should be removed from the area immediately surrounding the sensor. The use of vibrators immediately next to the gauge should be avoided. The standard cable has a thick PVC jacket and can be placed directly in the concrete.

3. TAKING READINGS

Connect the ten-pin connector to the GK-502 readout box or connect the bare wires to a voltage supply and millivoltmeter as follows:

Bendix Pin	Circuit Label	Description	GEOKON Purple Cable
A	S-	Bridge Output -	White's Black
B	P+	Bridge Excitation +	Red
C	P-	Bridge Excitation -	Red's Black
D	S+	Bridge Output +	White
E	NC	No Connection	NC
F	G	Ground for shield	Shield
G	T	Thermistor	Blue
H	T	Thermistor	Blue's Black
J	RS+	Remote Sense +	Green
K	RS-	Remote Sense -	Green's Black

Table 1 - Input Connections

3.1 Circuit Diagram
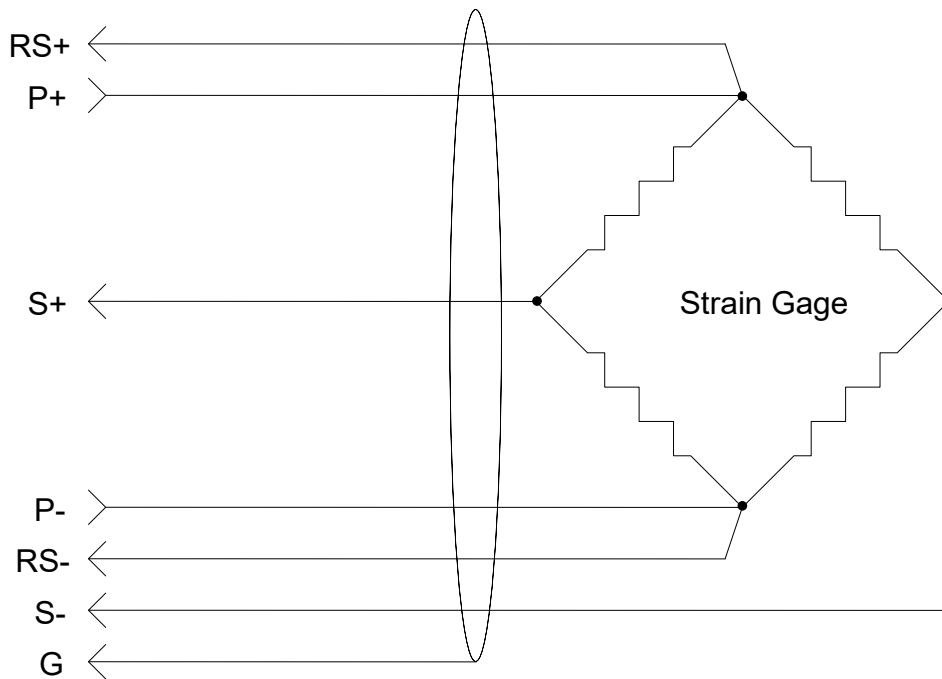
Figure 1 - Circuit Diagram

3.2 Using the GEOKON GK-502 Readout Box

The user is referred to the GK-502 Instruction Manual for additional information on the following instructions:

1) Connect the embedment gauge to the readout box by means of the 10-pin input connector.

2) Press the 'ON/OFF' button power switch to the "ON" position.

3) Press the 'UNITS' button until the UNITS displayed are mV/V.

4) Read the display and record.

5) See the GK-502 Instruction Manual for further instructions.

4. DATA REDUCTION

4.1 Displacement Calculation

The basic units utilized by GEOKON for measurement and reduction of data from Model 3900 Embedment Strain Gauges are mV/V.

If a GK-502 readout box is used, **mV/V** can be displayed directly.

The displacement **D** is given by the equation:

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

Equation 1 - Displacement

Where;
D is the displacement in the units given on the calibration report provided with the instrument.
R_0 is the initial GK-502 reading in mV/V.
R_1 is the current GK-502 reading in mV/V.
G is the calibration factor in inches/mV/V, as supplied on the Cal Sheet. (See Appendix C. for a sample calibration report.)

If a regulated power supply and a millivoltmeter are used, then calculate the mV/V by dividing the displayed millivolt output by the voltage input measured at the sensor using the remote signal leads, (Green and Green's Black).

4.2 Strain Calculation

To calculate the **strain ε,** divide the measured displacement **D** by the gauge length **L.**
The standard length for **L** is Eight inches (203 mm).

Example: Using a GK-502, R_0 = -0.8640 and R_1 = -0.5563, G = 0.05193 inches/mV/V.
Strain ε = ((-0.5563-(-0.8640) x 0.05193/8 = +2000 microstrain (tension)

Note that an increasing reading denotes a tensile strain.

4.3 Temperature Correction Factor

Tests have shown that the temperature effect is such that the embedment gauge reading goes up (extension) as the temperature goes up and the required temperature correction factor is plus 22.5 microstrains per °C.

So, for example, using the GK-502 (displaying mV/V) to take the readings, and a standard eight-inch-long gauge, where **G** is given in inches/mV/V, the calculation for strain **S**, corrected for temperature change **(T$_1$ - T$_0$)** measured in degrees Centigrade, is:

$$S = (R_1 - R_0)(G)\left(\frac{1,000,000}{8}\right) - 22.5(T_1 - T_0) \text{ microstrain}$$

Equation 2 - Strain Calculation with Temperature Correction

APPENDIX A. SPECIFICATIONS

Standard Range[1]:	5000 microstrain
Accuracy:	± 0.25% FS
Linearity:	<1.0% FSR
Resolution:	± 0.025% FSR
Repeatability:	0.3% FSR
Temperature Effect:	22.5 $\mu\epsilon$ /°C
Temperature Range:	−20 to +80° C 0 to 110° F
Active Gauge Length[2]	203 mm (8")
Input Resistance:	350Ω
Output Resistance:	350 Ω
Excitation Voltage:	2 to 15 V DC
Maximum Excitation Voltage:	30 V
Cable Type:	Four twisted pair (eight conductor) 22 AWG Foil shield, PVC jacket, nominal OD=9.5 mm (0.375")

Table 2 - Specifications

Notes
[1] Other ranges are available on request**.**
[2] Other gauge lengths available on request.

APPENDIX B. 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 3 - Resistance to Temperature

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	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 3 - Thermistor Resistance Versus Temperature

APPENDIX C. TYPICAL CALIBRATION REPORT

GEOKON.

Resistance Strain Gauge Calibration Report

This Calibration has been Verified/ Validated as of: March 03, 2022

Serial Number: 2208576

Calibration Date: March 3, 2022

Temperature: 23.6

Calibration Instruction: CI-3900

Technician:

Average Displacement (inches)	Reading 1st Cycle (mV/V)	Reading 2nd Cycle (mV/V)	Average Reading (mV/V)	Calculated Linear Displacement (inches)	Error Linear (%FS)	Calculated Polynomial Displacement	Error Polynomial (%FS)
0.0000	0.9243	0.9258	0.9250	-0.00011	-0.28	0.00000	-0.01
0.0080	1.0845	1.0858	1.0851	0.00802	0.04	0.00799	-0.02
0.0160	1.2443	1.2450	1.2446	0.01611	0.28	0.01603	0.06
0.0240	1.4010	1.4020	1.4015	0.02408	0.19	0.02399	-0.02
0.0320	1.5568	1.5585	1.5576	0.03200	0.00	0.03198	-0.05
0.0400	1.7130	1.7135	1.7133	0.03990	-0.25	0.04001	0.03

Linear Gage Factor (G): 0.05076 **(inches/ mV/ V)**

Polynomial Gage Factors: **A:** 0.0013139 **B:** 0.04730 **C:** _____

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

Calculated Displacement: **Linear, $D = G(R_1 - R_0)$**

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

Figure 2 - Typical Calibration Report