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Instruction Manual

Model 4400

VW Embedment Jointmeter

(Doc Rev L.1, 05/01/23)

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EQUATIONS

1. THEORY OF OPERATION

GEOKON Model 4400 Vibrating Wire Embedment Jointmeters are intended primarily for the measurement of joint openings between lifts or sections in mass concrete or across fracture zones in fully grouted boreholes.

The instrument consists of a vibrating wire sensing element in series with a heat treated, stress relieved spring which is connected to the wire at one end and a connecting rod at the other. As the connecting rod is pulled out from the gauge body, the spring is elongated causing an increase in tension and a resulting change in frequency of the vibrating wire sensing element. The tension in the wire is directly proportional to the extension, hence, the opening of the joint can be determined very accurately by measuring the frequency change with the vibrating wire readout box. The unit is fully sealed and operates at pressures of up to 250 psi.

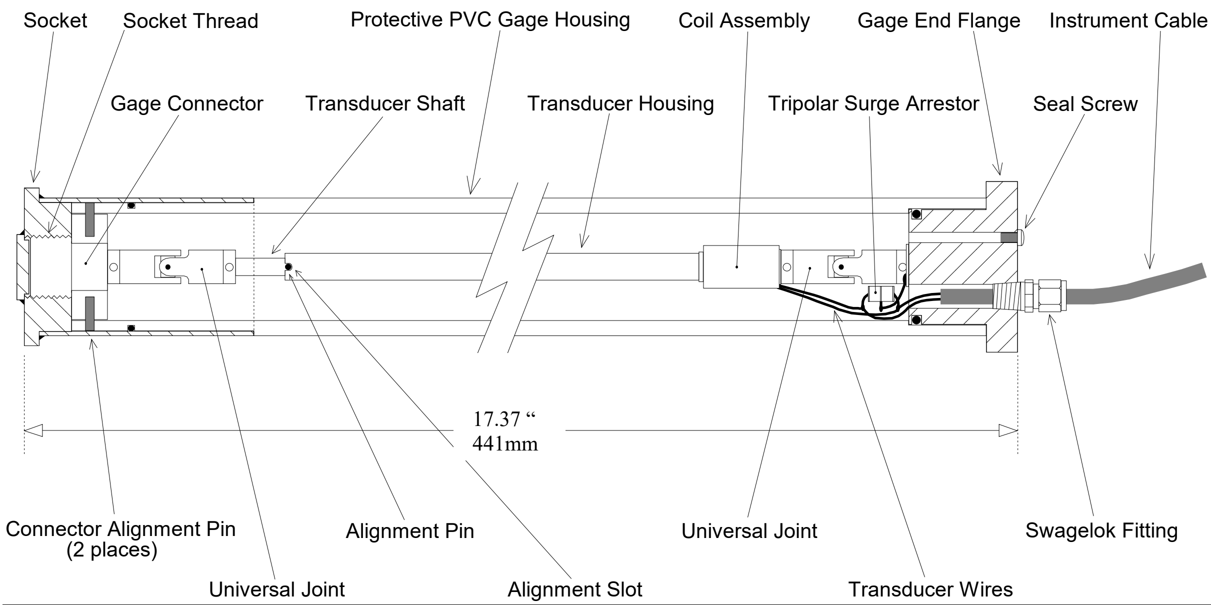

Figure 1 - Model 4400 Vibrating Wire Embedment Jointmeter

In use, a socket is placed in the first lift of concrete and, when the forms are removed, a protective plug is pulled from the socket. The gauge is then screwed into the socket, extended slightly and then concreted into the next lift. Any opening of the joint is then measured by the gauge which is firmly anchored in each lift. The sensing gauge itself, is smaller than the protective housing, and a degree of shearing motion is allowed for by the use of universal ball-joint connections on the gauge.

A thermistor is also located inside the vibrating wire jointmeter housing for the measurement of temperature at the jointmeter location. In addition, a tripolar plasma surge arrestor inside the housing provides protection for the sensor coils from electrical transients such as may be induced by direct or indirect lightning strikes.

2. INSTALLATION

2.1 Removing the Shipping Spacer

2.1.1 All 4400 Models Except Those with a 12.5 mm (0.5") Range:

1) Locate the shipping spacer on the socket thread end of the instrument (will be marked with a white label).

2) Unwrap the tape that is holding the spacer in place.

3) There is an approximate 3 mm (0.125") lip on the shipping spacer that rests inside the sensor housing. Carefully pull on the socket thread until it is extended far enough to allow the shipping spacer to be slid out of the housing and removed. **CAUTION!** Do not extend the connector more than the range of the gauge. Do not twist the socket thread more than 45 degrees in relation to the rest of the sensor.

4) After the shipping spacer has been removed, allow the socket thread to retract back into the housing. **Make sure that the pins engage in the slots in the plastic housing as shown in Figure 2 below.**

2.1.2 For 12.5 mm (0.5") Range Models:

4400 models that have a range of 12.5 mm (0.5") do not have a shipping spacer. Complete the following to prepare the instrument:

1) Unwrap the tape that is holding the socket thread end of the instrument in place.

2) Carefully rotate the socket thread end counterclockwise until **the pins engage in the slots in the plastic housing as shown in Figure 2. CAUTION!** Do not extend the connector more than the range of the gauge. Do not twist the socket thread more than 45 degrees in relation to the rest of the sensor.

Figure 2 - Pin Engaged in Slot

2.2 Preliminary Tests

The gauge should be checked for proper operation prior to use (including the thermistor). In position "B" the gauge will read around 2000 when the threaded connector is pulled out approximately 3 mm (0.125"). (See Section 3 for readout instructions.) **Do not extend the connector more than the range of the gauge.** The threaded connector on the end of the gauge should not be turned independently of the gauge body.

Checks of electrical continuity can also be made using an ohmmeter. Resistance between the gauge leads should be approximately 180 Ω, ±10 Ω. Remember to add cable resistance when checking (22 AWG stranded copper leads are approximately 14.7Ω/1000' or 48.5Ω/km, multiply by two for both directions). Between the green and white should be approximately 3000 ohms at 25° (see Table 4 in Appendix B), and between any conductor and the shield should exceed two megohms.

2.3 Embedment Jointmeter Installation

The installation of the Vibrating Wire Embedment Jointmeter consists of two stages; first, installing the socket and, second, installing the gauge.

2.3.1 Installing the Socket

The socket of the gauge is meant to be installed in the first lift of concrete. The socket comes with a PVC plug held in place by two o-rings. This plug is designed to keep concrete from entering the inside of the socket and to hold the socket in place while the concrete is poured. After installation the face of the socket must coincide with the finished face of the concrete if it is to be accessible. If the socket plug is removed and needs to be replaced it will be necessary to temporarily remove the socket plug bolt so that the air inside the socket can escape when the plug is forced back into the socket.

The protective socket plug is supplied with a ¼-20 x 1-inch bolt which can be used to bolt the socket to the forms. (As shown in Figure 3.)

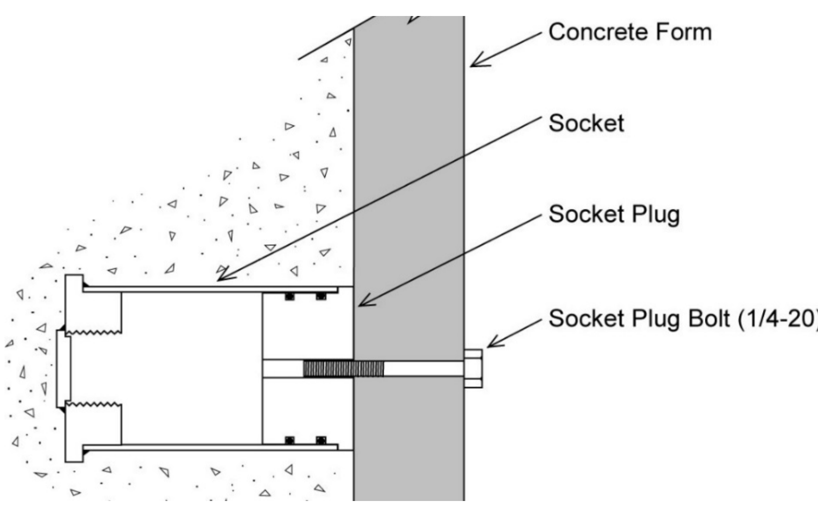

Figure 3 - Socket Installation

2.3.2 Installing the Jointmeter.

1) After the forms have been stripped and socket exposed, the socket plug should be removed using the socket plug bolt or, if necessary, one of the eyebolts supplied. The bore of the socket is supplied covered with o-lube to facilitate the assembly. Make sure that the inside of the socket is clean and greased before proceeding.

2) Before pushing the jointmeter into the socket, **make sure that the pins in the connector engage the slots in the plastic housing. (See Figure 4). This is very important.**

Figure 4 - Showing Pin Engaged in Slot

3) Remove the seal screw from the cable end flange. (Refer to Figure 1 in Section 1.) This allows air to enter the inside of the jointmeter while it is being adjusted.

4) Push the gauge into the socket until it stops. While applying an inward pressure, rotate the gauge in a clockwise direction, for approximately four revolutions until the connection is snug in the socket thread. Note: If the stiff direct burial cable is being used, the cable bundle or reel should also be rotated to avoid crimping the cable. **Again, it is very important that the pins in the connector are inside the slots of the PVC housing. If the pins are not in the slots and the jointmeter is twisted the jointmeter will be broken**.

5) The next step is to secure the gauge body and cable in position for placing concrete. Readings should be taken on the gauge (and thermistor) at this time (see Section 3).

2.3.3 Setting the Initial Reading

2.3.3.1 Models 4400 –25, 4400-50, 4400-100, 4400-150

To allow for slight compression of the gauge, it is recommended that the gauge be pulled out until a reading of **3000-3500 in position 'B'** is obtained. This will set the gauge at approximately 25% of its range in tension. It should be remembered that the gauge should not be rotated after pulling it from the socket. After extending the gauge, wrap two to three layers of electrical tape around the gauge tube immediately adjacent to the socket to hold the gauge at this reading while the concrete is being placed. If the gauge must be removed from the socket, it **MUST** be pushed back in until the pins catch and then rotated counter-clockwise until it comes loose.

2.3.3.2 Model 4400-12

The above procedure for the longer-range models is not recommended for the 4400-12 model. Here the danger of over-ranging the sensor due to the sudden release, when pulling the gauge out, is too great. So, leave the gauge as is. The natural compression of the gauge a will be enough to allow for any small amount of joint closure.

Don't forget to reinstall the 10-32 × 3/8" seal screw into the gauge end flange.

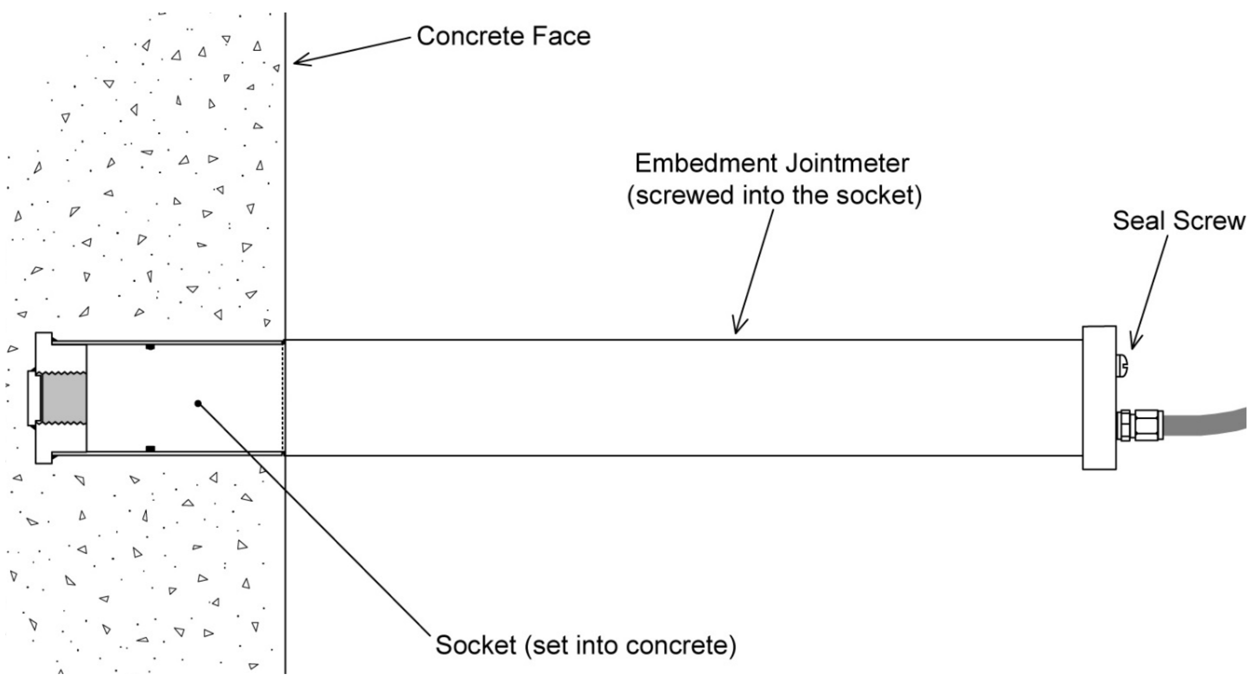

Figure 5 - Completed Embedment Jointmeter Installation

2.4 Cable Installation

The cable should be routed in such a way to minimize the possibility of damage due to moving equipment, debris or other causes.

Cables may be spliced to lengthen them, without affecting gauge readings. Always waterproof the splice completely, preferably using an epoxy-based splice kits available from the factory.

2.5 Electrical Noise

Care should be exercised when installing instrument cables to keep them as far away as possible from sources of electrical interference such as power lines, generators, motors, transformers, arc welders, etc. **Cables should never be buried or run with AC power lines!** The instrument 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.

2.6 Initial Readings

<u>Initial readings must be taken</u> and carefully recorded along with the temperature at the time of installation. Take the initial readings while the gauge is in position, just prior to placing the second lift of concrete. Take readings again after the second lift of concrete has cured.

3. TAKING READINGS

3.1 GK-404 Readout Box

The Model GK-404 Vibrating Wire Readout is a portable, low-power, handheld unit that can run continuously for more than 20 hours on two AA batteries. It is designed for the readout of all GEOKON vibrating wire gauges and transducers; and is capable of displaying the reading in either digits, frequency (Hz), period (μs), or microstrain (με). The GK-404 also displays the temperature of the jointmeter (embedded thermistor) with a resolution of 0.1 °C.

3.1.1 Operating the GK-404

Before use, attach the flying leads to the GK-404 by aligning the red circle on the silver "Lemo" connector of the flying leads with the red line on the top of the GK-404 (Figure 6). Insert the Lemo connector into the GK-404 until it locks into place.

Figure 6 - Lemo Connector to GK-404

Connect each of the clips on the leads to the matching colors of the sensor conductors, with blue representing the shield (bare).

To turn the GK-404 on, press the "ON/OFF" button. The initial startup screen will be displayed. After approximately one second, the GK-404 will start taking readings and display them based on the settings of the POS and MODE buttons.

The unit display (from left to right) of the GK-404 is as follows:

- The current Position: Set by the **POS** button, displayed as a letter A through F.
- The current Reading: Set by the **MODE** button, displayed as a numeric value followed by the unit of measure.
- Temperature reading of the attached gauge in degrees Celsius.

Use the **POS** button to select position **B** and the **MODE** button to select **Dg** (digits). The GK-404 will continue to take measurements and display readings until the unit turned off, either manually, or if enabled, by the Auto-Off timer.

For further information, consult the GK-404 manual.

3.2 GK-405 Readout Box

The GK-405 Vibrating Wire Readout is made up of two components: The Readout Unit, consisting of a Windows Mobile handheld PC running the GK-405 Vibrating Wire Readout Application; and the GK-405 Remote Module, which is housed in a weatherproof enclosure and connects via a cable to the vibrating wire gauge to be measured. The two components communicate wirelessly. The Readout Unit can operate from the cradle of the Remote Module, or, if more convenient, can be removed and operated up to 20 meters from the Remote Module.

3.2.1 Connecting Sensors

Sensors with 10-pin Bulkhead Connectors Attached:
Align the grooves on the sensor connector (male), with the appropriate connector on the readout (female connector labeled senor or load cell). Push the connector into place, and then twist the outer ring of the male connector until it locks into place.

Sensors with Bare Leads:
Attach the GK-403-2 flying leads to the bare leads of a GEOKON vibrating wire sensor by connecting each of the clips on the leads to the matching colors of the sensor conductors, with blue representing the shield (bare).

3.2.2 Operating the GK-405

Press the button labeled "POWER ON". A blue light will begin blinking, signifying that the Remote Module is waiting to connect to the handheld unit. Launch the GK-405 VWRA program by tapping on "Start" from the handheld PC's main window, then "Programs" then the GK-405 VWRA icon. After a few seconds, the blue light on the Remote Module should stop flashing and remain lit. The Live Readings Window will be displayed on the handheld PC. Choose display mode "B".

Figure 7 shows a typical vibrating wire output in digits and thermistor output in degrees Celsius.

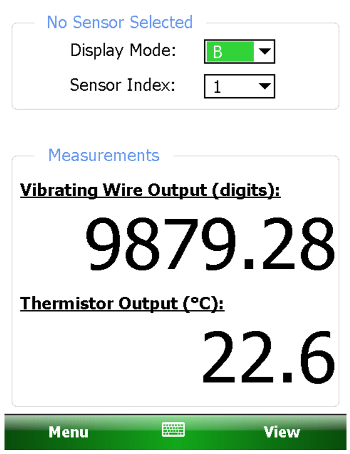

Figure 7 - Live Readings – Raw Readings

For further information, consult the GK-405 Instruction Manual.

3.3 GK-403 Readout Box (Obsolete Model)

The GK-403 can store gauge readings and apply calibration factors to convert readings to engineering units. The following instructions explain taking gauge measurements using Mode "B".

3.3.1 Connecting Sensors to the GK-403

Connecting Sensors with 10-pin Bulkhead Connectors Attached:
Align the grooves on the sensor connector (male), with the appropriate connector on the readout (female connector labeled senor or load cell). Push the connector into place, and then twist the outer ring of the male connector until it locks into place.

Connecting Sensors with Bare Leads:
Attach the GK-403-2 flying leads to the bare leads of a GEOKON vibrating wire sensor by connecting each of the clips on the leads to the matching colors of the sensor conductors, with blue representing the shield (bare).

3.3.2 Operating the GK-403

1) Turn the display selector to position "B".

2) Turn the unit on.

3) The readout will display the vibrating wire output in digits. The last digit may change one or two digits while reading.

4) The thermistor reading will be displayed above the gauge reading in degrees centigrade.

5) Press the "Store" button to record the value displayed.

The unit will automatically turn off after approximately two minutes to conserve power. Consult the GK-403 Instruction Manual for additional information.

3.4 Measuring Temperatures

All vibrating wire jointmeters are equipped with a thermistor, which gives a varying resistance output as the temperature changes. The white and green leads of the instrument cable are normally connected to the internal thermistor. The GK-404, and GK-405 readout boxes will read the thermistor and display the temperature in degrees C.

To read temperatures using an ohmmeter: Connect an ohmmeter to the green and white thermistor leads coming from the jointmeter. 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 14.7 Ω for every 1000 ft. (48.5Ω per km) at 20 °C. Multiply these factors by two to account for both directions. Look up the temperature for the measured resistance in Appendix B, Table 4.

4. DATA REDUCTION

4.1. Deformation Calculation

The basic units utilized by GEOKON for measurement and reduction of data from Vibrating Wire Jointmeters are "digits". The units displayed by the GEOKON readout in position "B" are digits. Calculation of digits is based on the following equation:

$$\text{Digits} = \left(\frac{1}{\text{Period}}\right)^2 \text{ x } 10^{-3}$$

Or

$$\text{Digits} = \text{Hz}^2 \text{ x } 10^{-3}$$

Equation 1 - Digits Calculation

To convert digits to deformation the following equation applies:

$$\text{Deformation} = (\text{Current Reading - Initial Reading}) \times \text{Calibration Factor} \times \text{Conversion Factor}$$

Or

$$D = (R_1 - R_0) \times G \times F$$

Equation 2 - Deformation Calculation

Where;
R_1 is the Current Reading.
R_0 is the Initial Reading usually obtained at installation.
G is the Calibration Factor, usually in terms of millimeters or inches per digit.
F is an engineering units conversion factor from Table 1 (this is optional).

From→ To↓	Inches	Feet	Millimeters	Centimeters	Meters
Inches	1	12	0.03937	0.3937	39.37
Feet	0.0833	1	0.003281	0.03281	3.281
Millimeters	25.4	304.8	1	10	1000
Centimeters	2.54	30.48	0.10	1	100
Meters	0.0254	0.3048	0.001	0.01	1

Table 1 - Engineering Units Conversion Multipliers

For example:

The Initial Reading (R_0) at installation of a jointmeter with a 12 mm transducer range is 3150 digits. The Current Reading (R_1) is 6000. The Calibration Factor is 0.00356 mm/digit. The deformation change is: D = (6000 – 3150) × 0.00356 = +10.146 mm

Note that increasing readings (digits) indicate increasing extension.

4.2. Temperature Correction

The Model 4400 Vibrating Wire Jointmeter has a very small coefficient of thermal expansion so in most cases correction is not necessary. However, if maximum accuracy is desired or the temperature changes are extreme (>10° C) corrections may be applied. The temperature coefficient of the mass in which the Jointmeter is embedded should also be taken into account. By correcting the transducer for temperature changes the deformation of the mass may be distinguished. The following equation applies;

$$D_{corrected} = ((R_1 - R_0) \times G) + ((T_1 - T_0) \times K) + L_C$$

Equation 3 - Thermally Corrected Deformation Calculation

Where;
R_1 is the Current Reading.
R_0 is the Initial Reading.
G is the Calibration Factor.
T_1 is the Current Temperature.
T_0 is the Initial Temperature.
K is the Thermal Coefficient.
L_C is the correction for the expansion/contraction of the universal joints and flanges.

Tests have determined that the Thermal Coefficient, K, changes with the position of the transducer shaft. Hence, the first step in the temperature correction process is determination of the proper Thermal Coefficient based on the following equation:

$$\text{Thermal Coefficient} = ((\text{Reading in Digits} \times \text{Multiplier}) + \text{Constant}) \times \text{Calibration Factor}$$

Or

$$K = ((R_1 \times M) + B) \times G$$

Equation 4 - Thermal Coefficient Calculation

Table 2 on the following page gives the Multiplier and Constant values used in Equation 4. The Multiplier (M) and Constant (B) values vary for the stroke of the transducer used in the Jointmeter.

Model:	4400-12 mm 4400-0.5"	4400-25 mm 4400-1"	4400-50 mm 4400-2"	4400-100 mm 4400-4"
Multiplier (M):	0.000375	0.000369	0.000376	0.000398
Constant (B):	1.08	0.572	0.328	0.0864
Length of joints, stand-offs and flanges, (L):	267 mm 10.5"	259 mm 10.2"	162 mm 6.38"	16 2 mm 6.38"

Table 2 - Thermal Coefficient Calculation Constants

The correction for expansion/contraction of the universal joints, stand-offs and flanges, (L_C), is calculated using Equation 5.

$$L_C = 17.3 \times 10^{-6} \times L \times (T_1 - T_0)$$

Equation 5 - Gauge Length Correction

Where;
L is from Table 2 in millimeters or inches, to match the Calibration Factor units.

Consider the following example using a Jointmeter with a 25 mm range transducer:

R_0 = 3150 digits
R_1 = 6000 digits
T_0 = 15.3° C
T_1 = 20.8° C
G = 0.00356 mm/digit
K = ((6000 × 0.000369) + 0.572) × 0.00356 = 0.0099
$L_C = 17.3 \times 10^{-6} \times 259 \times (20.8 - 15.3) = 0.024$
D =(6000 – 3150) x 0.00356 = 10.146 mm
$D_{corrected} = ((R_1 - R_0) \times C) + ((T_1 - T_0) \times K) + L_C$
$D_{corrected} = ((6000 - 3150) \times 0.00356) + (20.8 - 15.3) \times 0.0099) + 0.024$
$D_{corrected} = (2850 \times 0.00356) + (5.5 \times 0.0099) + 0.024$
$D_{corrected} = 10.146 + 0.054 + 0.024$
$D_{corrected} = +10.224$ mm

As can be seen from the above example, the corrections for temperature change are very small and can usually be ignored.

4.3. Environmental Factors

Since the purpose of the jointmeter installation is to monitor site conditions, factors which may affect these conditions should always be observed and recorded. Seemingly minor effects may have a real influence on the behavior of the structure being monitored and may give an early indication of potential problems. Some of these factors include, but are not limited to: blasting, rainfall, tidal levels, excavation and fill levels and sequences, traffic, temperature and barometric changes, changes in personnel, nearby construction activities, seasonal changes, etc.

5. TROUBLESHOOTING

Maintenance and troubleshooting of GEOKON Vibrating Wire Embedment Jointmeters is confined to periodic checks of cable connections and maintenance of terminals. Once installed, the Jointmeters are usually inaccessible and remedial action is limited. Consult the following list of problems and possible solutions should difficulties arise. Consult the factory for additional troubleshooting help.

Symptom: Jointmeter Readings are Unstable

✓ Is the readout box position set correctly? If using a datalogger to record readings automatically are the swept frequency excitation settings correct?

✓ Is the transducer shaft of the Jointmeter positioned outside the specified range of the instrument? Note that when the transducer shaft is fully retracted with the alignment pin inside the alignment slot (see Figure 1 in Section 1) the readings will likely be unstable because the vibrating wire is now out of range.

✓ 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 whether using a portable readout or datalogger. If using the GK-403 connect the clip with the blue boot to the shield drain wire. (Green for the GK-401.)

Symptom: Jointmeter Fails to Read

✓ Is the cable cut or crushed? This can be checked with an ohmmeter. Nominal resistance between the two transducer leads (usually red and black leads) is 180Ω, ±10Ω. Remember to add cable resistance when checking (22 AWG stranded copper leads are approximately 14.7 Ω/1000' or 48.5Ω/km). If the resistance reads infinite, or very high (>one megohm), a cut wire must be suspected. If the resistance reads very low (<100Ω) a short in the cable is likely. Splicing kits and instructions are available from the factory to repair broken or shorted cables. Consult the factory for additional information.

✓ Does the readout or datalogger work with another Jointmeter? If not the readout or datalogger may be malfunctioning.

APPENDIX A. SPECIFICATIONS

A.1 Model 4400 Embedment Jointmeter

Range:[1]	12 mm 0.50 inches	25 mm 1 inch	50 mm 2 inches
Resolution:	0.025% FSR		
Linearity:	0.25% FSR		
Accuracy:	0.5% FSR (0.1% FSR with a polynomial expression)		
Thermal Zero Shift:	< 0.05% FSR/°C		
Stability:	< 0.2%/yr (under static conditions)		
Overrange:	115%		
Temperature Range:	-40 to +60 °C		
Frequency Range:	1400 - 3500 Hz		
Coil Resistance:	180 Ω, ±10 Ω		
Cable Type:[2]	Two twisted pair (four conductor) 22 AWG Foil shield, PVC jacket, nominal OD=6.3 mm (0.250")		
Length: (compressed)	441 mm 17.37"		
Maximum Diameter: (flange)	63.5 mm 2.5"		
Tube Diameter:	50.8 mm 2.0"		
Weight:	1.5 kg 3.3 lb.		

Table 3 - Specifications

Notes:
[1] Consult the factory for other ranges available.
[2] Consult the factory for alternate cable types.

A.2 Thermistor (see Appendix B also)

Range: -80 to +150° C
Accuracy: ±0.5° C

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 6 - 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 4 - Thermistor Resistance versus Temperature