Model 4400

VW Embedment Jointmeter

Instruction Manual

GEOKON

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TABLE OF CONTENTS

1. INTRODUCTION

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.

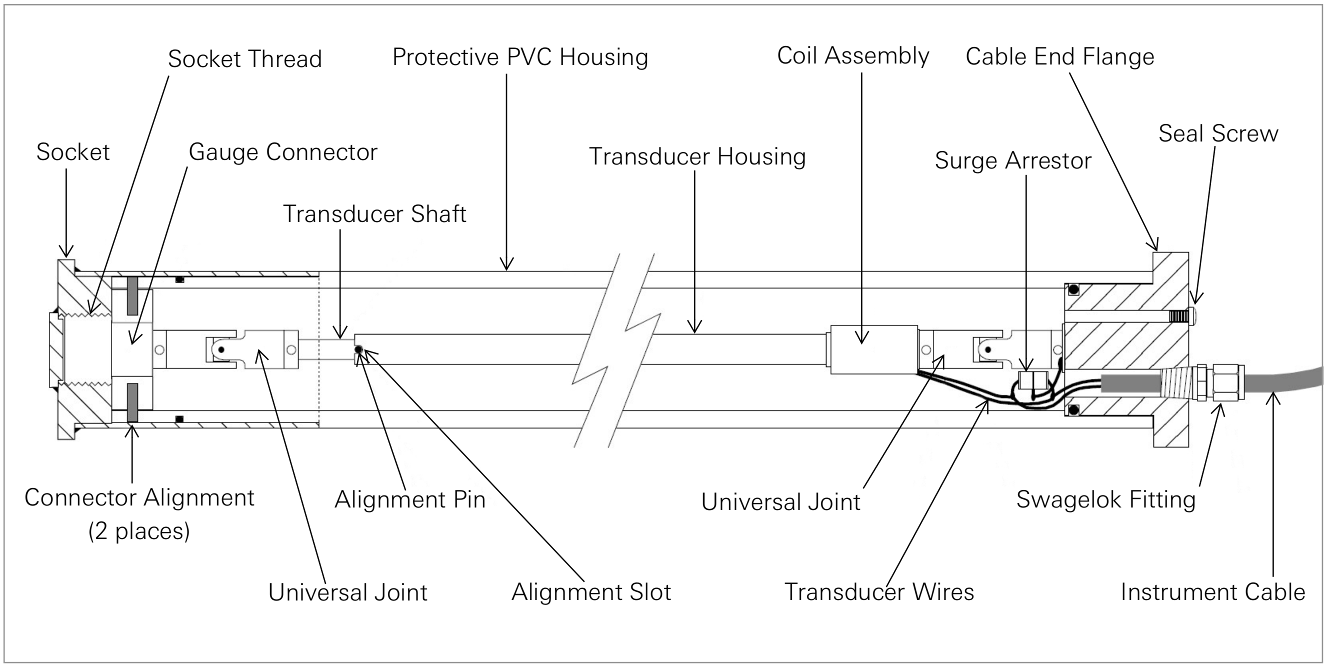

FIGURE 1: *Model 4400 Vibrating Wire Embedment Jointmeter*

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

The process for removing the spacer is different depending on the model number.

2.1.1 MODEL 4400-12.5 MM (0.5") ONLY:

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*

2.1.2 ALL OTHER MODELS:

3. Locate the shipping spacer, marked with a white label, on the socket thread end of the instrument.
4. Unwrap the tape that is holding the spacer in place.
5. 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.

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.**

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 compatible readouts.) **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 48.5Ω/km or 14.7Ω/1000', multiply by two for both directions). Between the green and white should be approximately 3000 ohms at 25° (see 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 jointmeter.

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 1/4-20 x 1-inch bolt which can be used to bolt the socket to the forms as shown in Figure 3.

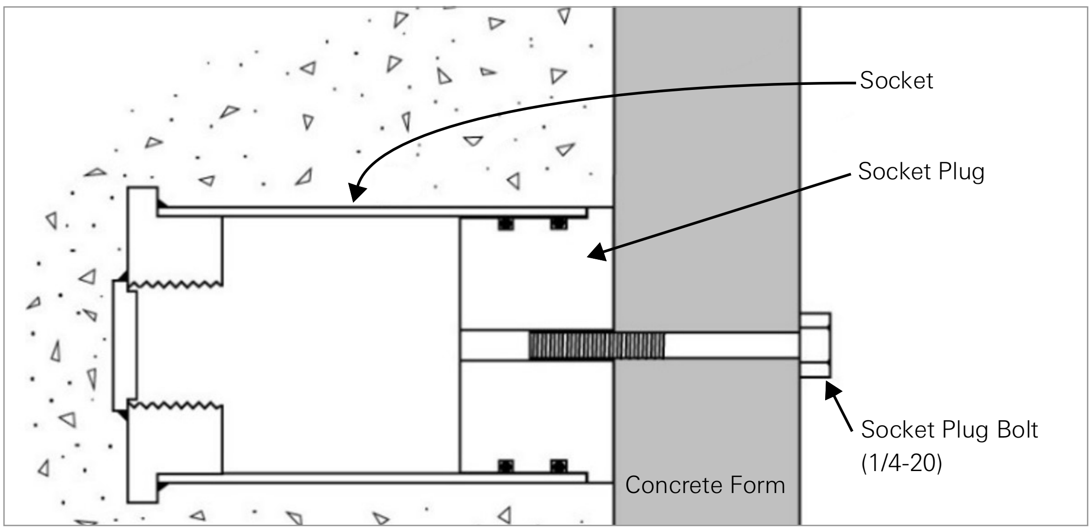

FIGURE 3: *Socket Installation*

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: *Pin Engaged in Slot*

3. Remove the seal screw from the cable end flange. This allows air to enter the inside of the jointmeter while it is being adjusted.

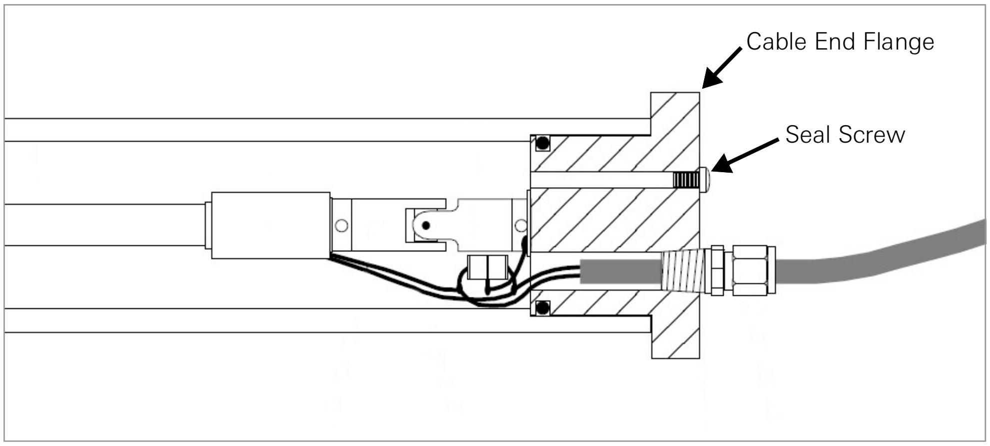

FIGURE 5: *Seal Screw Location*

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.

Important! 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).

2.4 SETTING THE INITIAL READING

The process for setting a gauge is different depending on the model number.

2.4.1 MODEL 4400-12.5 MM (0.5") ONLY:

The typical procedure for the longer-range models is not recommended for Model 4400-12.5 MM. 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.

2.4.2 ALL OTHER MODELS:

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. **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.

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

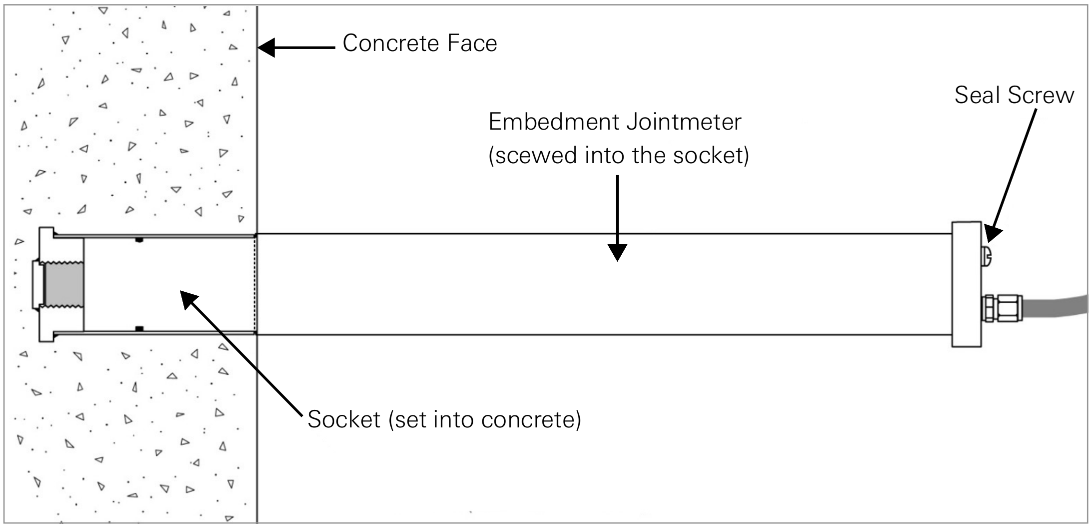

FIGURE 6: *Completed Embedment Jointmeter Installation*

2.5 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.

2.6 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.

2.7 INITIAL READINGS

Initial readings must be taken 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 COMPATIBLE READOUTS AND DATALOGGERS

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

Readouts

DIGITAL READOUTS:

- **GK-404**

  The Model GK-404 VW Readout is a portable, low-power, hand-held unit capable of running for more than 20 hours continuously on two AA batteries. It is designed for the readout of all GEOKON Vibrating Wire (VW) instruments, and is capable of displaying the reading in digits, frequency (Hz), period (µs), or microstrain (µε). The GK-404 displays the temperature of the transducer (embedded thermistor) with a resolution of 0.1 °C.

- **GK-406**

  The Model GK-406 is a field-ready device able to quickly measure a sensor, save data, and communicate results with custom PDF reports and spreadsheet output. Measurements are geo-located with the integrated GPS allowing the GK-406 to verify locations and lead the user to the sensor locations. The large color display and VSPECT^{TM} technology create confidence of getting the best measurement possible both in the field and in the office.

Dataloggers

DATALOGGERS:

- **8600 Series**

  The MICRO-6000 Datalogger is designed to support the reading of a large number of GEOKON Vibrating Wire 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.

- **8800 and 8900 Series**

  The GeoNet Wireless Mesh Data Acquisition system consists of a Gateway and subordinate Wireless Mesh Data Loggers that transmit data collected from the connected sensors. The Gateway controls the network and is the aggregator of all the data from the Loggers in the system. The Cellular and Wi-Fi Gateways transfer the collected data to the GEOKON Cloud data storage platform, where it is securely stored and can be viewed in GEOKON Agent Software or exported to a third-party software platform through the Open API. A Local Gateway (no cellular or Wi-Fi capabilities) is available for applications where the data is to remain local or a third-party modem or ethernet connection is desired.

- **8920, 8930, and 8950 Series**

  GEOKON Model 8920, 8930, and 8950 Series Loggers offer a high-value, networked data collection option for all GEOKON Vibrating Wire instruments and digital sensor (MEMS IPI and VW) strings. Each logger comes from the factory ready for deployment and may commence with data acquisition in minutes.

  Sensor data is collected and transferred via a cellular, Wi-Fi, or satellite network to a secure cloud-based storage platform where it can be accessed through the GEOKON OpenAPI. Industry leading data visualization software, such as the free GEOKON Agent program, can be used with the OpenAPI for data viewing and reporting. Commissioning, billing and configuration are accomplished via the easy-to-use GEOKON API Portal.

■ **8940 Series**

GEOKON Model 8940 Series Dataloggers offer a high-value data collection option for all GEOKON Vibrating Wire instruments and digital sensor strings. Waterproof single and four-channel GeoNet dataloggers housed inside rugged PVC enclosures are also available. Each logger is ready to be installed from the factory and acquires data in minutes.

Sensor data is collected on site by connecting the 8940 to a P.C. and using the free GEOKON Agent software program for data viewing and reporting.

3.2 MODEL 4999 TERMINAL BOXES

Model 4999 Manual

Terminal boxes with sealed cable entries are available from GEOKON. These allow many gauges 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.

Terminal Boxes make it easy to manually connect a Readout Box (GK-404 or GK-406). The rotary switch is used to select which “channel” or sensor is being read by the Readout Box.

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

3.3 MEASURING TEMPERATURES

All GEOKON vibrating wire instruments are equipped with a thermistor for reading temperature. The thermistor 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-406 readouts will read the thermistor and display the temperature in degrees Celsius.

USING AN OHMMETER TO READ TEMPERATURES:

Connect an ohmmeter to the green and white thermistor leads coming from the instrument. 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.

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:

$$\text{digits} = \left(\frac{1}{\text{Period}}\right)^2 \times 10^{-3} \quad \text{or} \quad \text{digits} = \frac{\text{Hz}^2}{1000}$$

EQUATION 1: *Digits Calculation*

To convert digits to deformation the following equation applies:

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

EQUATION 2: *Deformation Calculation*

Where:
R_0 = The initial reading in digits.
R_1 = The current readings in digits.
G = The calibration factor, usually in terms of millimeters or inches per digit.
F = An engineering units conversion factor from the table below (this is optional).

		CONVERT FROM				
		Inches	**Feet**	**Millimeters**	**Centimeters**	**Meters**
CONVERT TO	**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 digits. The calibration factor is 0.00356 mm/digit. The deformation change is:

$$D = (6000 - 3150) \times 0.00356$$

$$D = 10.146 \text{ mm}$$

Note that increasing (positive) readings 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_0 = The initial reading in digits.
R_1 = The current readings in digits.
G = The calibration factor, usually in terms of millimeters or inches per digit.
T_1 = The current temperature.
T_0 = The initial temperature.
K = The thermal coefficient.
L_C = 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:

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

EQUATION 4: *Thermal Coefficient Calculation*

Where:
R_1 = The current readings in digits.
M = The multiplier.
B = The constant
G = The calibration factor, usually in terms of millimeters or inches per digit.

Table 2 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.

Range	**12 mm (0.5")**	**25 mm (1")**	**50 mm (2")**	**100 mm (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")	162 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 = Length from the previous table in mm or inches, to match the calibration factor units.
T_1 = The current temperature.
T_0 = The initial temperature.

FOR EXAMPLE:

Consider the following readings taken 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

First, calculate the thermal coefficient:

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

$$K = ((6000 \times 0.000369) + 0.572) \times 0.00356 = 0.0099$$

Calculate the gauge length correction:

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

$$L_C = 17.3 \times 10^{-6} \times 259 \times (20.8 - 15.3) = 0.024$$

Calculate the deformation:

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

Note: F is optional, and not used in this example.

$$D = (6000 - 3150) \times 0.00356 = 10.146 \text{ mm}$$

Calculate the thermally corrected deformation:

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

$$D_{corrected} = ((6000 - 3150) \times 0.00356) + ((20.8 - 15.3) \times 0.0099) + 0.024 = 10.224 \text{ mm}$$

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

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 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 2 in Section 2) 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.

SYMPTOM: SENSOR FAILS TO GIVE A READING

- ☐ 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 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). If the resistance reads infinite, or very high (>one megohm), a cut wire must be suspected. If the resistance reads very low (<100 Ω) 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 SPECIFICATIONS

Range[1]	12 mm (0.50")	25 mm (1")	50 mm (2")	100 mm (4")
Resolution	±0.025% F.S.			
Linearity	±0.25% F.S.			
Accuracy	0.5% F.S. (0.1% F.S. with a polynomial expression)			
Thermal Zero Shift	< 0.5% F.S./°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, ±10Ω			
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"			568.3 mm 22.375"
Maximum Diameter (Flange)	63.5 mm 2.5"			63.5 mm 2.5"
Tube Diameter	50.8 mm 2.0"			50.8 mm 2.0"
Weight	1.5 kg 3.3 lb.			1.6 kg 3.6 lb

TABLE 3: *Model 4400 VW Embedment Jointmeter Specifications*

Note:

[1] Other ranges available.

[2] Other cable types available.

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:

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

EQUATION 6: *3KΩ Thermistor Resistance*

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	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*

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Vibrating Wire Displacement Transducer Calibration Report

Model: 4400-1-50MM

Serial Number: 2322021

Calibration Instruction: CI-4400

Cable Length: 24 meters

Calibration Date: November 08, 2023

This calibration has been verified/validated as of 09/04/2024

Temperature: 20.9 °C

Technician:

GK-401 Reading Position B

Actual Displacement (mm)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Displacement (Linear)	Error Linear (%FS)	Calculated Displacement (Polynomial)	Error Polynomial (%FS)
0.0	3248	3247	3248	-0.08	-0.15	-0.01	-0.01
10.0	4122	4122	4122	10.02	0.04	10.01	0.02
20.0	499	499	499	20.06	0.	20.00	0.0
30.0	5856	5856	5856	30.04	0.08	29.99	-0.02
40.0	6719	6719	6719	40.01	0.01	40.00	-0.01
50.0	7578	7580	7579	49.94	-0.13	50.00	0.01

(mm) Linear Gauge Factor (G): 0.01155 **(mm/ digit)** **Regression Zero:** 3254

Polynomial Gauge Factors: **A:** 2.6525E-08 **B:** 0.01126 **C:** ______________

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

(inches) Linear Gauge Factor (G): 0.0004546 **(inches/digit)**

Polynomial Gauge Factors: **A:** 1.0443E-09 **B:** 0.0004433 **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, $D = AR_1^2 + BR_1 + C$

Refer to manual for temperature correction 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 7: *Typical Calibration Report*

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