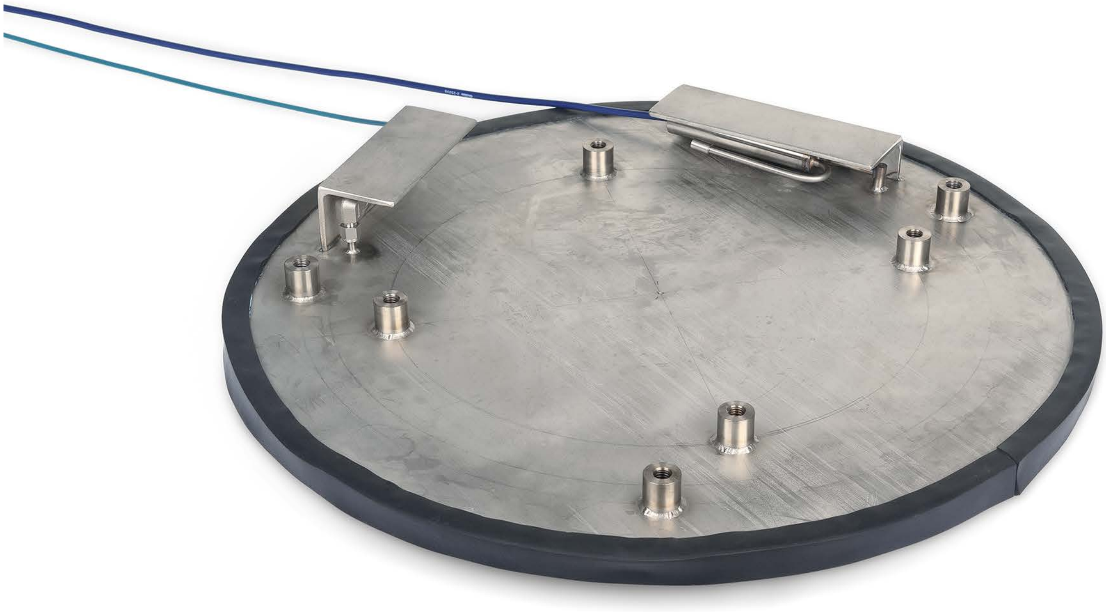
Model 4855

Pile Tip Pressure Cell

Instruction Manual



GEOKON

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1. INTRODUCTION

The GEOKON Model 4855 Pile Tip Pressure Cell is used to measure pile-tip loads in cast-in-place concrete piles (caissons). The basic cell is manufactured to be close to the diameter of the pile.

The pressure cell is comprised of two circular stainless steel plates welded together around their periphery, leaving a thin space between the plates filled with de-aired hydraulic oil. This oil filled space is connected via a pressure tube to a vibrating wire pressure sensor. End-bearing pressure applied normal to the plate is balanced by a corresponding build-up of internal oil pressure, which is measured by the sensor. The use of de-aired hydraulic oil guaranties that the modulus of the pile tip pressure cell is equal to or greater than the modulus of the surrounding concrete. This ensures that the pressure measured by the cell is characteristic of the pressure across the entire cross-section of the borehole and that there is minimal error created by a certain amount of the load being transmitted directly through the concrete around the edges of the pressure cell.

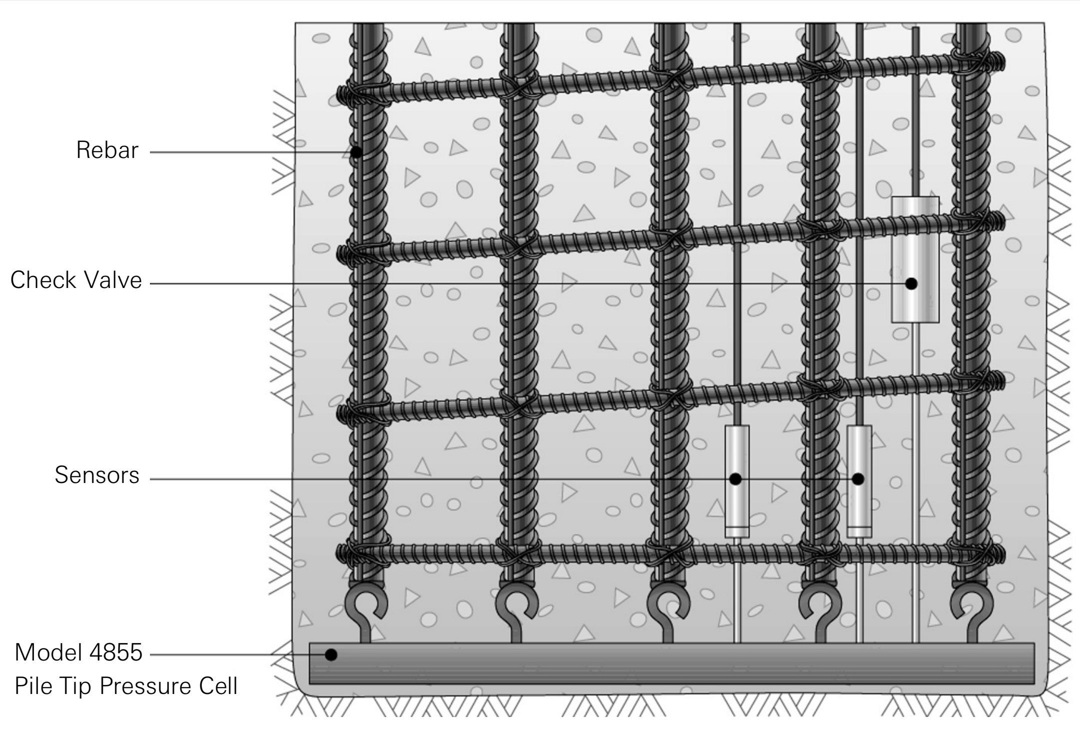


FIGURE 1: *Model 4855 Pile Tip Pressure Cell*

Lugs are provided on the back of the upper plate for welding to the rebar cage. Lugs are also welded to the lower plate for attachment of short lengths of rebar, which are designed for pre-embedment in a concrete cone or cylinder, covering the entire lower plate. This cone, or cylinder, depending on the shape of the bottom of the excavated shaft, prevents the formation of voids beneath the pressure cell caused by the entrapment of air or water.

During concrete curing, temperatures very often rise and will cause the cell to expand in the still green concrete. On cooling, the cell contracts leaving a space between it and the surrounding concrete which, if allowed to remain, might prevent the transmission of pressures from the concrete to the cell. To overcome this, provision is made so that the cell can be inflated until it comes back into perfect contact with the concrete on both surfaces. This re-inflation is performed from the surface through a hydraulic line operating through a check valve. An alternative method, using a pinch tube and remote crimping device, is also available.

The vibrating wire sensors are modified Geokon Model 4800 transducers with a fully welded pressure cavity. The sensors are hermetically sealed and are connected via waterproof connectors to an electrical cable leading to the surface. The sensor housings also incorporate a thermistor that permits measurement of temperature at the cell location.

1.1 THEORY OF OPERATION

The ability of cast-in-place piles to support a load relies on friction along the pile and on end bearing. The load distribution along the pile can be measured by embedding strain gauges at different depths along the pile and by comparing the measured strains at different depths with the strains at the top of the pile, very close to the applied load, which are assumed to be equivalent to 100% of the applied load. This ratio method does not require knowledge of the concrete modulus. Another method, to determine the actual end-bearing load taken by the pile tip is to measure it directly by installing a pressure cell between the pile tip and the ground below. Application of the load to the top of the pile causes pressure to be developed inside the pile tip pressure cell and this pressure, when multiplied by the area of the pile tip pressure cell, is directly equivalent to the end bearing load.

2. INSTALLATION CONSIDERATIONS

2.1 REBAR CAGE

The bottom of the rebar cage should have some standard form of support for the pressure cell. These standard designs include a steel cross at the bottom and a steel belt around the periphery, adjacent to the bottom. These features require that tapped lugs be welded on the upper plate of the cell at specific locations to match corresponding holes drilled in the cross-piece.

2.2 CABLE INSTALLATION AND SPLICING

The cable should be routed to minimize the possibility of damage due to moving equipment, debris or other causes. The cable can be protected using flexible conduit, which can be supplied by GEOKON.

Because the vibrating wire output signal is a frequency rather than a current or voltage, cable splicing has no ill effects. The cable used for making splices should be a high-quality twisted pair type, with 100% shielding and an integral shield drain wire. **It is very important that the shield drain wires be spliced together.** Always maintain polarity when possible by connecting color to color.

Splice kits recommended by GEOKON incorporate casts that are placed around the splice and are then filled with epoxy to waterproof the connections. When properly made, this type of splice is equal or superior to the cable in strength and electrical properties. Contact GEOKON for splicing materials and additional cable splicing instructions.

2.3 ELECTRICAL NOISE

Care should be exercised when installing sensor 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 sensor 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.

3. INSTALLATION

3.1 PRELIMINARY TESTS

Before installation, check the sensor for proper functioning. Each sensor is provided with a no load zero reading. The sensor electrical leads are connected to a readout box (see Section 4 for compatible readouts) and the zero reading given on the calibration report is now compared to a current zero reading. The two readings should not differ by more than ≈50 digits after due regard to corrections made for different temperatures, barometric pressures, height above sea level, and actual cell position (whether standing up or laying down).

Take Initial No-Load Reading of pressure and temperature with the cell laying flat on the ground. These are important readings and will be used in future calculations of pile-tip load.

By standing on the cell, it should be possible to change the readout digits, causing them to decrease as the pressure is increased.

Checks of the insulation can also be made using an ohmmeter. Resistance between any conductor and the shield should exceed 50 megohms. The thermistor inside the sensor can also be checked.

3.2 PILE TIP PRESSURE CELL INSTALLATION

3.2.1 FORM THE CONCRETE CONE

1. Thread the short pieces of rebar into the lugs welded to the bottom side of the pressure cell (opposite from the sensor side) to form two circles of rebar; short rebar on the outside circle and longer ones nearer the center.
2. Excavate a depression in the ground and line with sand. The shape of the depression should match the profile of the bottom of the pile shaft, whether conical or cylindrical.
3. Fill the depression with concrete of the same type as the rest of the pile and heap in the middle. Lower the pile tip pressure cell onto the heap, the concrete should extrude outwards carrying any voids with it. Allow the concrete to cure. (See an example of a concrete cone in Figure 2.)

3.2.2 ATTACHING THE PRESSURE CELL TO THE REBAR CAGE

The lugs protruding from the top side of the pressure cell are welded to the rebar of the rebar cage using the following procedure:

1. Thread the eyebolts into the lugs welded to the top side of the pressure cell.
2. Hook the provided hooks and chains to the eyebolts. Use the chains to lift the cell and position it close to the bottom of the rebar cage, within 2 m (6.6′).
3. Route the cables and hydraulic lines along the rebar cage, leaving an extra 2 m (6.6′) of slack between the cell and the bottom of the cage.
4. Tie a 1 m (3.28′) steel rope to one of the eyebolts and to the bottom of the cage.

Note: The purpose of the steel rope is to make sure that the cables and hydraulic lines cannot be ripped off when the rebar cage is lifted from the horizontal to the vertical.

5. Lift the cage to a vertical position and lower it over the cell. The bottom of the cage should be guided by at least two people to prevent it from twisting and swinging.
6. Line up the holes in the crosspiece with the threaded lugs on the pressure cell. Use the provided bolts to secure the cell to the crosspiece. Remove the chains from the eyebolts.
7. Bend three pieces of rebar, approximately 1.5 m (4.9′) long, into a hook shape at one end. Hook into the eyebolts and weld the straight ends to the rebar cage.

FIGURE 2: *Pressure Cell (With Concrete Cone) Installed on the Rebar Cage*

3.2.3 ENCASE IN CONCETE

1. Ensure that the bottom of the hole is clean of debris. Fill the hole with wet concrete to a depth of approximately 30 cm (12"). It is important that there be no voids below the cell.
2. Lower the assembly into the shaft. While lowering the cage into the shaft the cables and the hydraulic line are tensioned and fastened to the longitudinal rebars of the cage with cable ties approximately every 1 m (3.28'). The cables and hydraulic line should be positioned so that they are protected from the concrete tremie pipe and from being scraped as the rebar cage is lowered into the hole.
3. When the pressure cell is seated at the bottom, fill the hole with concrete. Take readings of pressure and temperature at regular intervals throughout the filling process. It should be possible to monitor the pressure of the wet concrete as it is poured.
4. Allow the concrete to cure and cool to a temperature close to ambient.
5. It may be observed that there is a drop-in cell pressure from the value observed with the wet cement when the hole was filled. Connect the cell re-inflation line to a hydraulic hand pump filled with de-aired oil and pump oil into the cell while observing the pressure reading. The cracking pressure of the check valve is set so that it will open at a higher pressure than the static head of oil in the re-pressurization tube plus any suction that will be generated by the weight of the concrete attached to the lower plate. **Stop pumping as soon as the pressure begins to rise sharply above this value and reaches the wet cement value.** Disconnect the pump from the hydraulic line and cap the end of the re-pressuring tube.

4. TAKING READINGS

4.1 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 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.

- **GeoNet Series**

  The GeoNet series is designed to collect and transfer data from vibrating wire, RS-485, and analog instruments. GeoNet offers a wide range of telemetry options, including LoRa, cellular, Wi-fi, satellite, and local. Loggers can work together to operate in a network configuration, or be used separately as standalone units. GeoNet devices arrive from the factory ready for deployment and may commence with data acquisition in minutes.

  Data is transferred 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 Software, can be used with the OpenAPI for data viewing and reporting. Dataloggers without network capabilities are also available.

Model 4999 Manual

4.2 MODEL 4999 TERMINAL BOXES

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

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

4.3 MEASURING TEMPERATURES

Each sensor is equipped with a thermistor for reading temperature. The thermistor gives a varying resistance output as the temperature changes. Connect an ohmmeter to the thermistor leads coming from the sensor. 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.

5. DATA REDUCTION

5.1 DATA CALCULATION

The basic units utilized by GEOKON for measurement and reduction of data from this sensor are digits. The 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*

In typical installations the linear calculation is more than sufficient. However, if utmost accuracy is desired, the polynomial calculation can be used. Refer to the applicable section below.

5.1.1 LINEAR CALCULATION

To convert digits to pressure the following equation applies:

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

EQUATION 2: *Linear Pressure Calculation*

Where:
G = The gauge factor found on the calibration report, usually in terms of kPa, MPa, or psi per digit.

R_1 = The current readings in digits.
R_0 = The initial field zero reading in digits.

The Initial Reading (R_0) is normally obtained during installation (usually the zero reading). Make sure that the sensor has achieved temperature stability.

EXAMPLE:

The initial reading (R_0) at installation of the sensor is 8300 digits. The current reading (R_1) is 6300 digits. The calibration factor (G) is -0.0008854 MPa/digit. The pressure change is:

$$P = -0.0008854(6300 - 8300)$$

$$P = 1.77\ \text{MPa}$$

5.1.2 POLYNOMIAL CALCULATION

To convert digits to pressure using the polynomial expression the following equation applies:

$$P = AR_1^{\ 2} + BR_1 + C$$

EQUATION 3: *Polynomial Pressure Calculation*

Where:
R_1 = The current reading in digits.
A, B = The polynomial gauge factors found on the calibration report.
C = The polynomial gauge factor that needs to be calculated (see below).

To perform the polynomial calculation, gauge factor “C” must be calculated first. This is done by using the equation above, but replacing “P” with a value of zero, and “R_1” with the value of “R_0”.

$$0 = AR_0^2 + BR_0 + C$$

EQUATION 4: *Calculation for Polynomial Gauge Factor “C”*

Where:
R_0 = The initial field zero reading in digits.
A, B = The polynomial gauge factors found on the calibration report.

The calculated “C” can then be used in Equation 3 to find the precise value of pressure (P).

EXAMPLE:

The given polynomial gauge factors on the calibration are:

A = -4.63E^{-09}

B = -0.0008161

The initial reading (R_0) at installation of the sensor is 8300 digits. The current reading (R_1) is 6300 digits.

First, the gauge factor “C” must be calculated:

$$0 = AR_0^2 + BR_0 + C$$

$$0 = -4.63\times10^{-9} \times 8300^2 + (-0.0008161) \times 8300 + C$$

$$0 = -7.09 + C$$

$$C = 7.09$$

The displacement change is:

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

$$D = -4.63\times10^{-9} \times 6300^2 + (-0.0008161) \times 6300 + 7.09$$

$$D = 1.76\ \text{MPa}$$

5.2 OPTIONAL CALCULATIONS

5.2.1 TEMPERATURE CORRECTION

The cell is quite sensitive to temperature fluctuations. Equation 5 below shows the temperature correction for the VW transducer only, and usually this effect is insignificant and can be ignored. There are spurious temperature effects caused by the mismatch between temperature coefficients of the cell and surrounding concrete. This effect is not quantifiable in the laboratory and, hence, no correction factor for this effect can be supplied.

The following thermal correction equation (which only applies to the VW transducer) is calculated, then afterwards is added to the deformation calculation (Equation 2 or Equation 3):

$$T_{Correction} = K(T_1 - T_0)$$

EQUATION 5: *Thermal Correction for Pressure*

Where:
K = The thermal factor found on the calibration report, usually in terms of kPa, MPa, or psi per digit.

T_1 = The current temperature reading in °C.
T_0 = The initial field temperature reading in °C.

5.2.2 BAROMETRIC CORRECTION

The sensor is sealed and will respond to barometric pressure fluctuation. However, since the magnitudes are only on the order of ±0.5 psi, correction is generally not required. If a correction for these fluctuations is required, then it is necessary to record the barometric pressure at the time of each reading.

The following barometric correction equation is calculated, then afterwards is subtracted from the deformation calculation (Equation 2 or Equation 3):

$$S_{\text{Correction}} = (S_1 - S_0) \times F$$

EQUATION 6: *Barometric Correction with Conversion Factor*

Where:
S_1 = The current barometer.
S_0 = The initial field zero barometer.
F = The conversion factor, see below for more detail.

Barometric pressure must be converted to the same engineering unit as the sensor pressure range (kPa or MPa). Barometric pressure is usually recorded in inches of mercury. The conversion factor (F) for inches of mercury to kPa is 3.3863 and from inches of mercury to MPa is 0.003386. Table 1 in Section 5.2.2 lists other common conversion factors.

5.2.3 ENGINEERING UNITS CONVERSION

To convert to a different engineering unit, take the result from data calculation (after other optional calculations have been completed, if applicable) and multiply it by the appropriate conversion multiplier from Table 1.

		Convert From											
		psi	**"H_20**	**'H_20**	**mm H_20**	**m H_20**	**"HG**	**mm HG**	**atm**	**mbar**	**bar**	**kPa**	**MPa**
Convert To	**psi**	1	.036127	.43275	.0014223	1.4223	.49116	.019337	14.696	.014503	14.5039	.14503	145.03
	"H_20	27.730	1	12	.039372	39.372	13.596	.53525	406.78	.40147	401.47	4.0147	4016.1
	'H_20	2.3108	.08333	1	.003281	3.281	1.133	.044604	33.8983	.033456	33.4558	.3346	334.6
	mm H_20	704.32	25.399	304.788	1	1000	345.32	13.595	10332	10.197	10197	101.97	101970
	m H_20	.70432	.025399	.304788	.001	1	.34532	.013595	10.332	.010197	10.197	.10197	101.97
	"HG	2.036	.073552	.882624	.0028959	2.8959	1	.03937	29.920	.029529	29.529	.2953	295.3
	mm HG	51.706	1.8683	22.4196	.073558	73.558	25.4	1	760	.75008	750.08	7.5008	7500.8
	atm	.06805	.002458	.029499	.0000968	.0968	.03342	.001315	1	.000986	.98692	.009869	9.869
	mbar	68.947	2.4908	29.8896	.098068	98.068	33.863	1.3332	1013.2	1	1000	10	10000
	bar	.068947	.002490	.029889	.0000981	.098068	.033863	.001333	1.0132	.001	1	.01	10
	kPa	6.8947	.24908	2.98896	.0098068	9.8068	3.3863	.13332	101.320	.1	100	1	1000
	MPa	.006895	.000249	.002988	.0000098	.009807	.003386	.000133	.101320	.0001	.1	.001	1

TABLE 1: *Engineering Units Conversion Multipliers*

5.3 ENVIRONMENTAL FACTORS

Since the purpose of the sensor installation is to monitor site conditions, factors that can affect these conditions should always be observed and recorded. Seemingly minor affects 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, traffic, temperature and barometric changes, weather conditions, changes in personnel, nearby construction activities, excavation and fill level sequences, seasonal changes, etc.

6. TROUBLESHOOTING

Technical Support

Maintenance and troubleshooting of the sensor is confined to periodic checks of cable connections and maintenance of terminals. Once installed, the sensor 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: THERMISTOR RESISTANCE IS TOO HIGH

☐ Check for an open circuit. Check all connections, terminals, and plugs. If a cut is in the cable, splice according to instructions in Section 2.2.

SYMPTOM: THERMISTOR RESISTANCE IS TOO LOW

☐ Check for a short circuit. Check all connections, terminals, and plugs. If a short is in the cable, splice according to instructions in Section 2.2.

☐ Water may have penetrated the interior of the sensor. There is no remedial action.

SYMPTOM: SENSOR READINGS ARE UNSTABLE

☐ 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.

☐ Does the readout or datalogger work with another sensor? If not the readout or datalogger may be malfunctioning.

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

SYMPTOM: SENSOR FAILS TO GIVE A READING

☐ Check the readout with another sensor to ensure it is functioning properly.

☐ The sensor may have been damaged by over-ranging or shock. Inspect for damage.

☐ Check the resistance of the cable by connecting an ohmmeter to the sensor leads. Cable resistance is about 48.5Ω per km (14.7Ω per 1000'). If the resistance is very high or infinite, the cable is probably broken. If the resistance is very low, the sensor conductors may be shorted. If a break or a short is present, splice according to the instructions in Section 2.2. Refer to the expected resistance for the various wire combinations below.

Vibrating Wire Sensor Lead Resistance Levels

Red/Black Coil Resistance ≅180Ω

Green/White 3000Ω at 25 °C

Any other wire combination will result in a measurement of infinite resistance.

Note: Tests should be performed with a quality multimeter to accurately show possibilities of shorts. Sensors should be disconnected from other equipment while performing resistance tests, this includes surge modules, terminals, multiplexers and dataloggers. Fingers cannot be touching the multimeter leads or sensor wires while testing.

Table 2 shows the expected resistance for the various wire combinations.

Table 3 is provided for the customer to fill in the actual resistance found.

Vibrating Wire Sensor Lead Grid - SAMPLE VALUES					
	Red	**Black**	**White**	**Green**	**Shield**
Red					
Black	**≅180Ω**				
White	Infinite	Infinite			
Green	Infinite	Infinite	**3000Ω at 25°C**		
Shield	Infinite	Infinite	Infinite	Infinite	

TABLE 2: *Sample Resistance*

Vibrating Wire Sensor Lead Grid - SENSOR NAME/##					
	Red	**Black**	**White**	**Green**	**Shield**
Red					
Black					
White					
Green					
Shield					

TABLE 3: *Resistance Worksheet*

APPENDIX A. SPECIFICATIONS

A.1 MODEL 4855 SPECIFICATIONS

Range[1]	2 MPa (300 psi), 3 MPa (450 psi), 5 MPa (750 psi), 7.5 MPa (1100 psi), 10 MPa (1500 psi), 20 MPa (3000 psi)
Resolution	± 0.025% F.S.
Linearity	< 0.25% F.S. (standard) < 0.1% F.S. (optional)
Accuracy[2]	0.1% F.S. with a polynomial expression
Over Range	1.5 x rated pressure
Temperature Range	-20 to +80 °C
Frequency Range	1400 - 3500 Hz
Coil Resistance	180 Ω, ±10Ω
Dimensions	Diameter to suit the pile. Thickness approximately 15.875 - 28.575 mm (0.625 - 1.125”)
Material	Stainless Steel
Cable Type	Two twisted pair (four conductor) 22 AWG Foil shield, PVC jacket, nominal OD=6.3 mm (0.250")

TABLE 4: *Model 4855 Vibrating Wire Pile Tip Pressure Cell Specifications*

Note:

[1] Other ranges available on request.

[2] Stated accuracy is for the pressure transducer alone. The total system accuracy (pressure transducer + pressure cell) is subject to site-specific variables.

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:

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

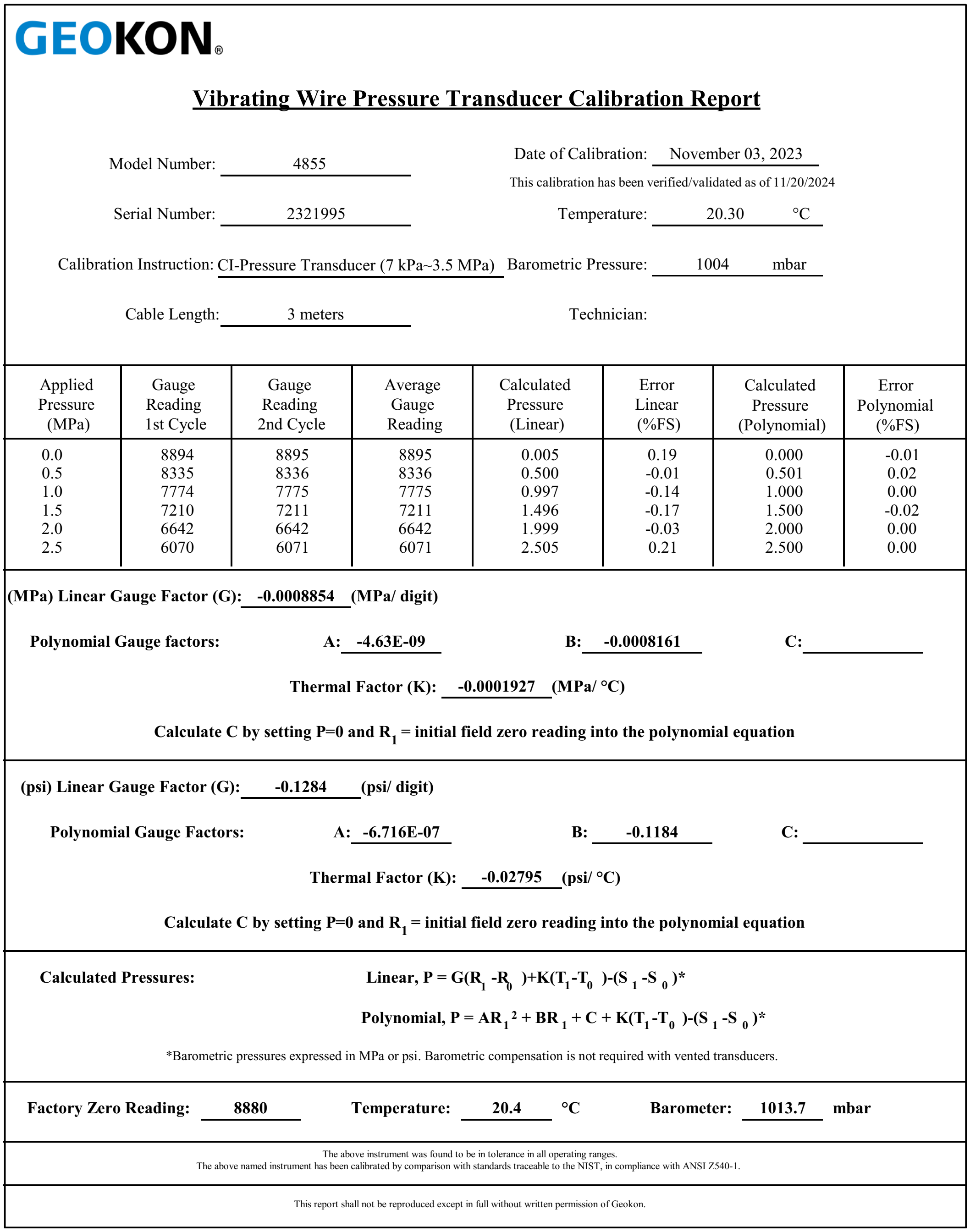
***EQUATION 7:** 3KΩ Thermistor Resistance*

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	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 5:** 3KΩ Thermistor Resistance*

APPENDIX C. TYPICAL CALIBRATION REPORT



GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4855

Date of Calibration: November 03, 2023

This calibration has been verified/validated as of 11/20/2024

Serial Number: 2321995

Temperature: 20.30 °C

Calibration Instruction: CI-Pressure Transducer (7 kPa~3.5 MPa)

Barometric Pressure: 1004 mbar

Cable Length: 3 meters

Technician:

Applied Pressure (MPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8894	8895	8895	0.005	0.19	0.000	-0.01
0.5	8335	8336	8336	0.500	-0.01	0.501	0.02
1.0	7774	7775	7775	0.997	-0.14	1.000	0.00
1.5	7210	7211	7211	1.496	-0.17	1.500	-0.02
2.0	6642	6642	6642	1.999	-0.03	2.000	0.00
2.5	6070	6071	6071	2.505	0.21	2.500	0.00

(MPa) Linear Gauge Factor (G): -0.0008854 (MPa/ digit)

Polynomial Gauge factors: A: -4.63E-09 B: -0.0008161 C:

Thermal Factor (K): -0.0001927 (MPa/ °C)

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

(psi) Linear Gauge Factor (G): -0.1284 (psi/ digit)

Polynomial Gauge Factors: A: -6.716E-07 B: -0.1184 C:

Thermal Factor (K): -0.02795 (psi/ °C)

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

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in MPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8880 Temperature: 20.4 °C Barometer: 1013.7 mbar

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.

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***FIGURE 3:** Typical Calibration Report*

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