Pneumatic Settlement Cell

51416399

This equipment should be installed, maintained, and operated by technically qualified personnel. Any errors or omissions in data, or the interpretation of data, are not the responsibility of Slope Indicator Company. The information herein is subject to change without notification.

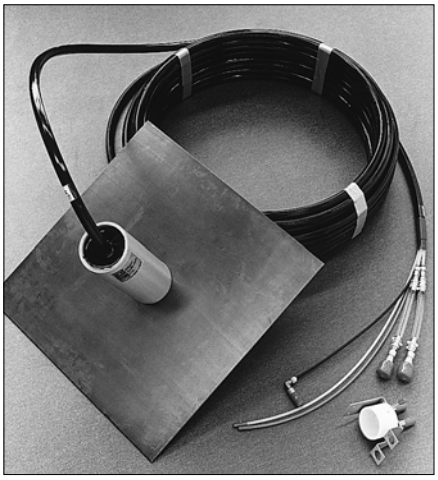
SLOPE INDICATOR
12123 Harbour Reach Drive
Mukilteo, Washington, USA, 98275
Tel: 425-493-6200 Fax: 425-493-6250
E-mail: solutions@slope.com
Website: www.slopeindicator.com

Contents

Introduction

Introduction

The pneumatic settlement cell is designed to measure settlements in construction areas which are inaccessible to standard optical survey techniques. It is especially useful in measuring large changes in settlement under earth dams, landfills, and soft soils.



Components include:

Settlement Cell

The cell is a plastic cylinder with a pneumatic transducer inside. Tubing is attached to the cell. An optional settlement plate may be included.

Tubing

Tubing consists of twin 1/4-inch tubes filled with a de-aired liquid and twin pneumatic tubes. The tubing permanently connected to the cell at the factory.

The surface end of the liquid filled tubing is terminated with expansion tubing and quick connectors, which will be attached to the reservoir.

The surface end of the pneumatic tubing is terminated with a dust plug on one tube and a quick connector on the other tube. The quick connector plugs into the pneumatic indicator.

Reservoir

The simple vented reservoir accommodates one settlement cell and is suitable for manual or automated readings. Its liquid level must be maintained regularly.

For best results, the reservoir should be placed at least 10 feet above the elevation of the cell. This provides a sufficient head of water for good operation the diaphragm.

Calibration Record

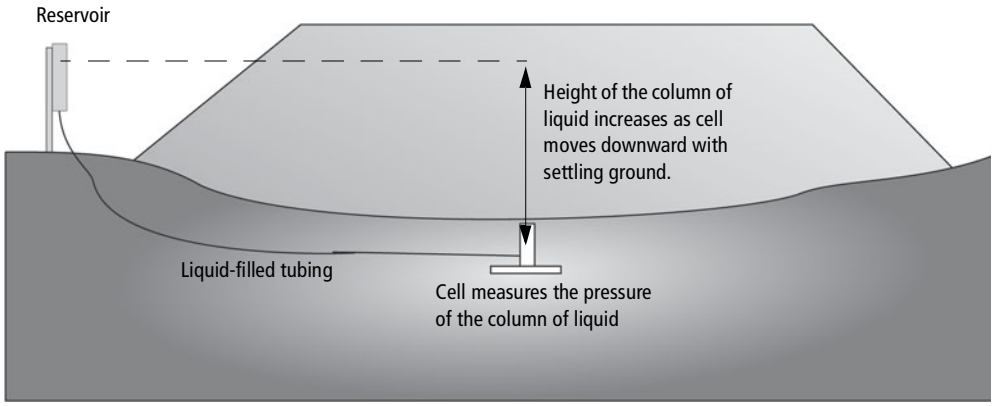
A calibration record is supplied with each cell. This calibration record is provided to certify that the cell has passed a quality control check. It is typically not used used in data reduction.

Theory of Operation

The settlement cell consists of three components: a liquid filled tube, a pressure transducer, and a reservoir of liquid. One end of the tubing is connected to the pressure transducer, which is embedded in the soil. The other end of the tubing is connected to the reservoir, which is located at a higher elevation on stable ground, away from construction activity.

The transducer measures the pressure created by the column of liquid in the tubing. The height of the column is equal to the difference in elevation between the transducer and the reservoir. As the transducer settles with the surrounding soil, the height of the column increases and the transducer measures a higher pressure.

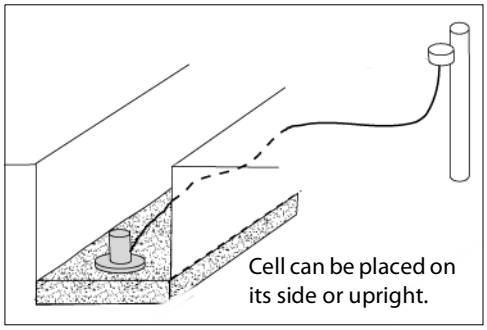
Settlement is calculated by converting changes in pressure to millimeters or inches of liquid head.



Installation of the Settlement Cell

Preparations

1. Stake out locations for the settlement cell, the reservoir, and the connecting trench.
2. Excavate the trench to the depth and width specified by the designer. Remove sharp stones and rocks and place a 100 mm layer of wet, fine sand on the bottom of the trench.



Install the Cell

1. Check that you have the correct cell and the correct length of tubing. A label on the cell shows its serial number.
2. Place the cell in the specified location. The cell works equally well on its side or upright.
3. The most vulnerable point in the system is where the tubing is connected to the cell. It is easiest to protect this point by placing the cell in the horizontal position, rather than the vertical position. The optional settlement place is not used in this case. If the cell must be place vertically, excavate a pit that will place the cell deep enough so that the tubing makes an easy bend to run into the trench.
4. (0ptional) Survey the exact elevation of the cell.
5. Cover the top of the cell with at least 100 mm of hand-compacted sand.

Install Tubing and Cable

1. Route tubing along the trench. Sometimes tubing is snaked along the trench in an attempt to prevent stretching or damage to the tubing as settlement occurs. This practice may not be entirely effective, since the tubing is not free to move when soil is packed around it. The vertical portion of the tubing sees the most tension. Running the tubing through vertical conduit is a possible countermeasure. Also, a strategically placed box, with a loop of tubing inside, can provide cable that can be freely pulled out as settlement occurs.
2. Place a layer of sand over the cable and tubing. Hand compact the sand. Then backfill the remainder of the trench, including

the portion with the cell, with hand-compacted select fill. Do this carefully, since later, it is likely that heavy machinery will drive across this area.

Install the Reservoir

1. Mount the reservoir on a wall or post that is outside the area affected by settlement. The best location would be one that keeps the reservoir out of direct sunlight and also minimizes the length of tubing that is above ground. The idea is to minimize temperature changes in the liquid. Note that you should probably test the system before mounting the reservoir permanently. See test instructions below.
2. Fill reservoir with deaired liquid. Allow liquid to bleed from quick-connect plugs. In the future, you will be replenishing the liquid in the reservoir when it evaporates. We recommend that you replace the evaporated liquid with just water, since water is the component that accounts for most of the evaporation. The water does not have to be deaired.
3. Fill quick-connect sockets (on tubing from cell) with deaired liquid, then press onto the quick-connect plugs. Note that liquid is under pressure in the tubing and excess liquid may splash out when you make the connection.

Test the System

This test checks the response of the cell to changes in the elevation of the reservoir. For best results, there should be about 3 meters or 10 feet of elevation difference between the reservoir and the cell.

1. Take a reading of the settlement cell. (See next chapter).
2. Move the reservoir upwards 0.5 meters from its initial position. Take another reading.
3. Move the reservoir downwards 0.5 meters from its initial position. Take a third reading.
4. Convert the readings to head of water. The second and third readings should show a 0.5 m change in head. Note that the calculated head is approximate, not absolute.
5. After testing, mount the reservoir at its permanent elevation

Obtain Initial Readings

Take an initial reading.

Taking Readings

Introduction

Instructions for reading pneumatic transducers can be found in the manual supplied with your pneumatic indicator. The pneumatic settlement cell is a twin-tube pneumatic transducer.

There are two ways to read pneumatic transducers: with flow and without flow. We present the flow method here, as done with the 256 pneumatic indicator. The flow method requires use of a flowmeter.

Prepare the Indicator

1. Before leaving for the site, check that you have enough gas in the tank. The tank pressure should be higher than 35 bar or 500 psi. Refill the tank, if necessary.
2. Check the regulated pressure. The regulated pressure must be no higher than the pressure rating of the pressure gauge. Turn the knob clockwise to increase the pressure or counter-clockwise to decrease the pressure.
3. Turn the tank control valve to the On position to supply gas to the indicator. You can leave the valve in this position most of the time.
4. Remember to take your jumper tubing. It is useful when connectors are hard to reach.
5. As a general rule, you should zero the pressure gauge on site. Refer to the indicator manual for instructions.

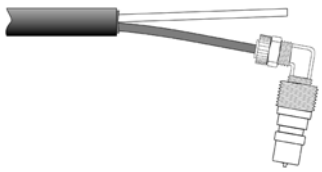
Maintain the Reservoir

Before every reading, always check the level of the water in the reservoir. It is best to add some water and allow the excess water to drain out.

1. Remove the reservoir cap.
2. Remove the plug from the reservoir overflow tube.
3. Add water to the reservoir until it runs out the overflow tube. Be sure to replace the plug and cap later, after you have taken a reading.

Connect the Tubing

1. The twin-tubing from the transducer contains a black tube and a clear (whitish) tube.
2. The black tube is terminated with a quick-connect plug. Connect the black tube to the indicator's transducer socket. If the plug is mounted in a panel, use the jumper to connect between panel-mounted plug and the indicator.



3. The clear tube is the vent tube. The vent tube may be protected by a dust cap. Remove the cap before you activate the transducer or you may be surprised by a pop when returning gas blows it off. Connect the vent tube to the return flow indicator or place it in a clear water-filled bottle.

Activate the Transducer

1. Turn the flow control valve to the On position.
2. If necessary, adjust the flow rate with the flow rate valve. The reading on the pressure gauge should increase at about 1 psi per second (slightly faster than 0.05 bar per second).
3. Wait for a return flow of gas from the vent tube. A return flow means that the transducer is active. he return flow signa If you are using a bubble bottle, watch for bubbles.

Tip: Transducers with longer lengths of tubing take more time to activate and read. Increasing the flow rate will not significantly reduce this time. In fact, a faster flow rate may result in a longer wait for the reading to stabilize because additional gas must flow through the transducer.

Take the Reading

1. Then, when you detect a return flow of gas, set the flow rate valve so that the flowmeter shows 30mm on its scale. This is equivalent to 47 cc/m or 0.1 SCFH.
2. Wait for the pressure reading to stabilize. With 500 feet of tubing, this takes about 90 seconds.
3. Tap the gauge and write down the reading.

Verify the Reading

1. Briefly turn the flow control valve to the Vent position. The purpose is to change the reading on the pressure gauge.
2. Wait for the reading to stabilize and compare it to the first reading. Repeat this process until you have repeatable readings.

Shut Down

1. Disconnect the tubing from the indicator and replace any dust caps. Pressure remaining in the transducer tubing helps keep out water.
2. If this is the last reading for the day, turn the tank control valve Off, turn the flow control to Vent, and turn the regulator knob counter-clockwise to reduce the regulated pressure to zero.
3. Replace the cap and overflow plug reservoir.

Data Reduction

Calibration Record

Calibration records are provided with each cell to certify that they have passed an inspection in manufacturing. Calibration records are not normally used in the data reduction process.

If you want to use the calibration record for data reduction, use the serial number of the sensor to find the appropriate calibration record. Then follow the data reduction formula printed on the calibration record.

Convert Pressure Reading to Head of Water

Convert the pressure reading from the transducer to head of water using one of the conversion factors below.

Head of Water = Corrected Cell Pressure x Conversion Factor

Starting Unit	Multiplier	Resulting Unit
psi	27.73	inch
	2.31	feet
	704.3	mm
	0.7043	m
bar	10215	mm
	10.215	m

Calculate Settlement

The change in head of water represents settlement or heave. If the change is positive, settlement has occurred. If the change is negative, heave has occurred:

Change in Water Head = Water Head $_{current}$ - Water Head $_{initial}$

Correcting for the Density of the Liquid

This is an optional correction and normally not necessary. Monitoring settlement typically involves changes, not absolute values. However, we present the information below for completeness.

The deaired liquid supplied with the settlement cell is a 50/50 mixture of water and ethylene glycol, which is about 7% heavier than water.

The table below shows how the density of the water/ethylene glycol mix varies with temperature. To calculate the actual head of liquid, divide the head of water value by the appropriate value in the table below. This is normally 1.07.

Before you decide to use these values, consider that the temperature of the column of liquid is unlikely to be uniform. Buried tubing in moderate climates tends to stay between 10 and 15 degrees C. However, the temperature of the liquid in tubing that is not buried, including the liquid in the reservoir, can vary significantly during the day.

Head of 50/50 Ethylene Glycol/Water = Water Head / Density Factor

Temperature,°C	Density Factor
-10	1.0800
-5	1.0775
0	1.0750
5	1.0725
10	1.0700
15	1.0672
20	1.0645
25	1.0617
30	1.0590
35	1.0560
40	1.0530

Troubleshooting

Problem	Possible Cause	Solution
Pressure reading too low	Supply pressure has dropped too low	Check gas supply
	Indicator circuits are venting	Turn control valve to halt venting
	Loose connection or damaged O-ring in quick-connect socket	Inspect O-ring and replace if necessary Clean and reconnect fitting
	Damaged tubing or bad splice	Splice tubing if accessible
Pressure reading too high or continues to increase	Input tube or vent tube is pinched or plugged	Check clear tube for blockages first, then check for return flow Check both tubes for pinching
	Piezometer is being activated at too high a flow rate	Reduce flow rate
	Quick-connect fitting is plugged	Clean and reconnect fitting
Erratic readings	Moisture or dirt in tubing	Purge tubing
	Damaged tubing	Replace tubing if accessible

How to Purge Pneumatic Tubing

1. Close all indicator valves.
2. Connect input tube (black) to input socket.
3. Check that vent tube is open to atmosphere.
4. Adjust supply pressure between 50 and 100 psi (345 to 690 kPa or 35 to 70 m H2O).
5. Pressurize piezometer.
6. Maintain gas flow to evaporate water or force it out of vent tube (10 to 30 minutes, depending on length of tubing).
7. Shut off gas supply.
8. Check reading. Repeat purge operation if reading is still erratic.