Multi-Level
VW Piezometer

52611199

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 Durham Geo Slope Indicator Company. The information herein is subject to change without notification.

SLOPE INDICATOR

Contents

Introduction

Operation

Multi-Level VW Piezometers are used to monitor pore-water pressure at different elevations in the borehole.

The multi-level system simplifies the process of installing multiple piezometers:

- Placement pipe ensures that piezometers are placed at the intended elevations.
- Signal cables run upwards inside the placement pipe rather than through the backfill. This eliminates possible leakage paths along the cables and also protects the cable. The placement pipe is later filled with grout.
- The entire borehole is backfilled filled with a bentonite cement grout. This isolates the intake zone of each piezometer and also eliminates the need for placing sand and bentonite plugs.

Signal cables are protected by PVC "placement" pipe.

PVC "placement" pipe makes it easy to place piezometers at the specified elevations.

Piezometers are installed in-line with the placement pipe.

Fully grouted borehole

Grout can be delivered through the PVC pipe in installations that are up to 30m (100ft) deep.
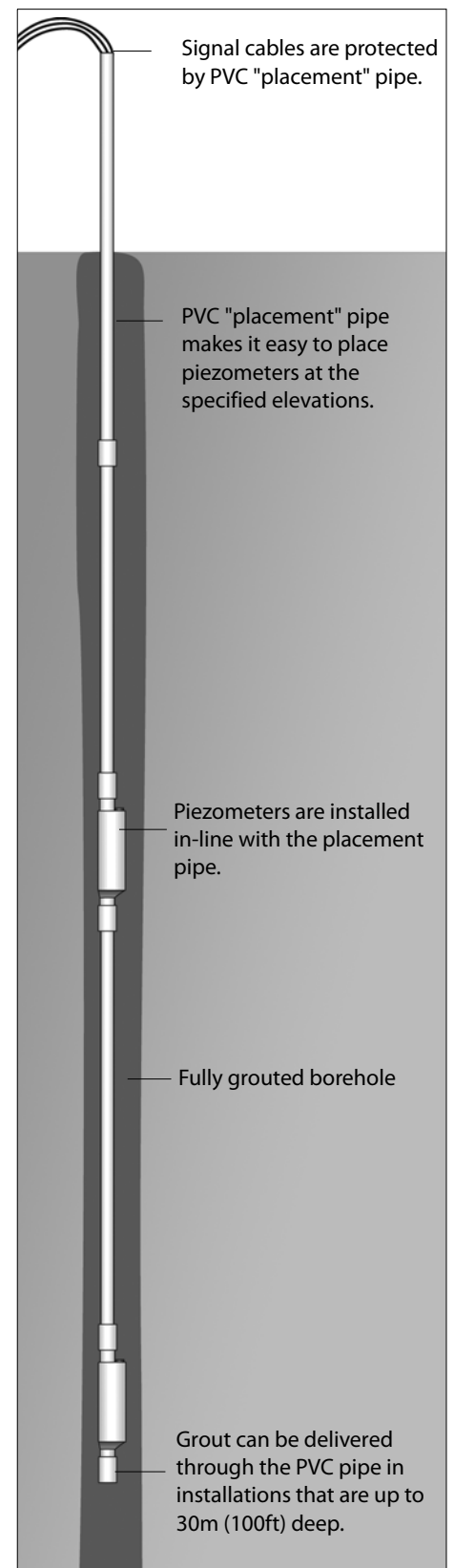
Components

Components include VW piezometers in multi-level housings and PVC placement pipe. Placement pipe consists of lengths of PVC pipe that run between multi-level housings and control the depth of each piezometer.
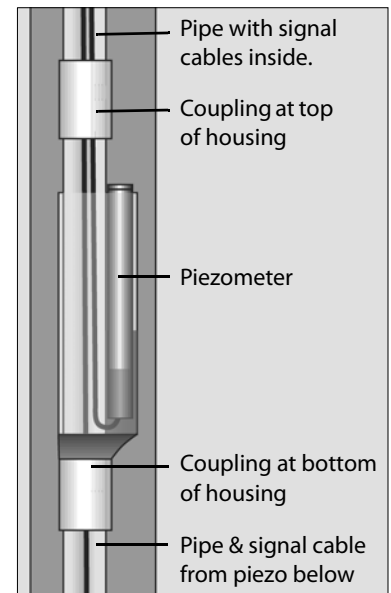
VW Piezometer in Multi-Level Housing

The drawing shows a cutaway of the multi-level housing. Couplings at top and bottom accept placement pipe. Signal cable from each sensor runs upwards through the placement pipe and housings.

The piezometer is held filter end up so that water placed in front of the diaphragm will not drain out during installation.

Serial Numbers: Piezometers are identified by their serial numbers. After the piezometer is installed, the only means of identifying it is the serial number label attached to the end of the cable. Take care that it is not cut off during or after installation.

Acceptance Test: We recommend that you test each piezometer as received. See Acceptance Tests later in this manual.

Pipe with signal cables inside.

Coupling at top of housing

Piezometer

Coupling at bottom of housing

Pipe & signal cable from piezo below

Grouting

- The multi-level system uses fully grouted bore-holes. More information on this technique can be found in technotes on the Slope Indicator website.
- If the borehole is less than 30m (100 feet) deep, you can usually grout the borehole through the placement pipe. An optional grout fitting, shown at right, is convenient in this case.
- If the borehole is more than 30m (100 feet) deep, an exterior grout pipe is more practical. If you use a flexible hose for grouting, you should install it with the piezometers. If you use a rigid pipe for grouting, you can insert it after the piezometers are in place.

Cable out

Grout in

Threaded bushing is glued to pipe.
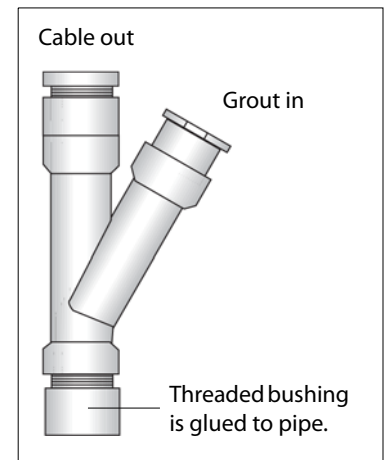
User-Supplied Components

- Placement pipe, couplings, and PVC cement. The multi-level housing accepts 1.25 inch, schedule 40 PVC pipe.
- Safety cable attached to the deepest piezometer to help retrieve the system if there is trouble during installation.
- Tape to protect ends of signal cables and hold cables together when pushing or pulling them through the placement pipe.
- A tubing cutter to cut off the placement pipe at the required height.
- External grout pipe, if needed.

Installation

Planning

1. Check project specifications to find the the intended depth of each piezometer.

2. Check cable lengths of piezometers (look on the serial number label) and mark them for order of installation.
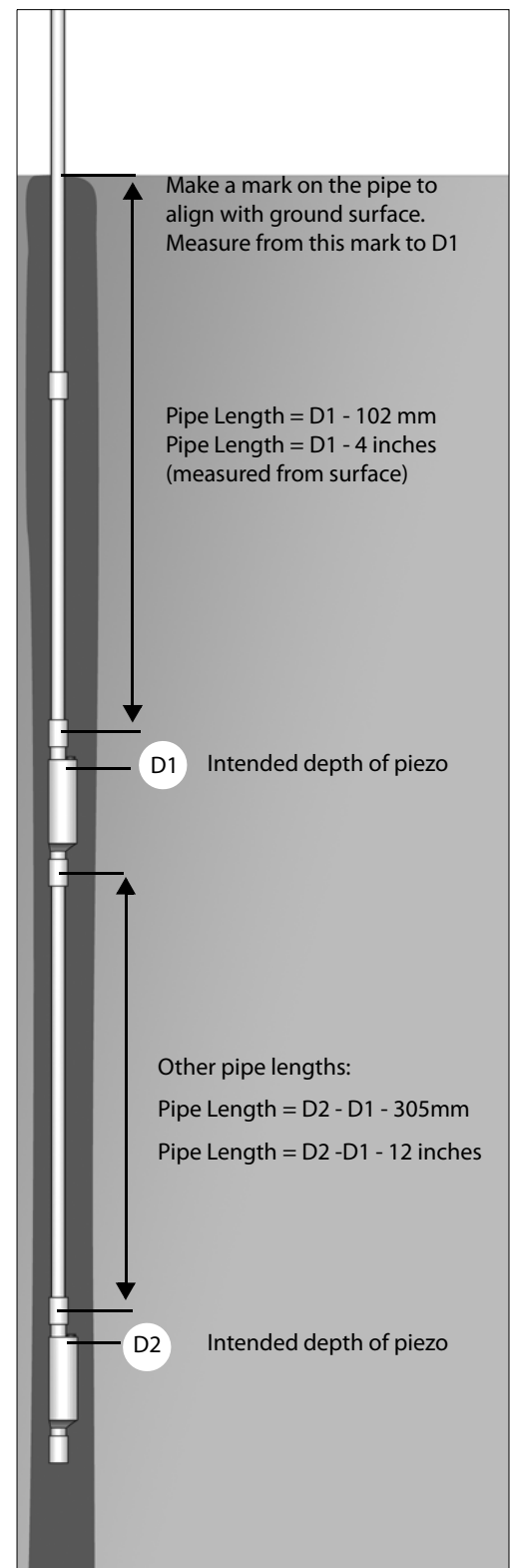
3. Lay out piezometers (no need to uncoil the cable yet. Use a measuring tape to place each piezometer at the proper distance from the "surface".

4. Lay out placement pipe alongside the piezometers and mark each length where it should be cut. The drawing at right may be helpful if precise placement is required.
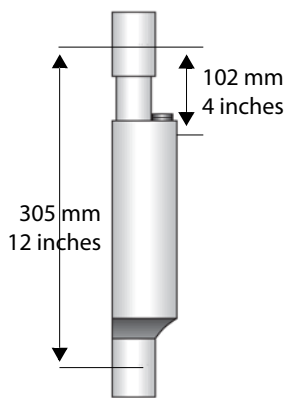
   D1 is the intended depth of the top piezometer. The length of the pipe - as measured from the surface- should be about 102 mm (4") shorter than D1 because the diaphragm of the piezometer is about 102mm below the middle of the coupling. Add some length to extend above the surface (for handling) and mark the pipe where it should align with the ground surface.

   D2 is the intended depth of the next piezometer. This time, the length of the pipe should be D2-D1-305mm (12 inches). That is because the multi-level housing is about 305mm long. Use the same calculation for D3, D4, and so on.

5. Cut the pipe to the marked lengths. Make sure to label the pipes for correct assembly later.

102 mm
4 inches

305 mm
12 inches

Make a mark on the pipe to align with ground surface. Measure from this mark to D1

Pipe Length = D1 - 102 mm
Pipe Length = D1 - 4 inches
(measured from surface)

D1 Intended depth of piezo

Other pipe lengths:
Pipe Length = D2 - D1 - 305mm
Pipe Length = D2 -D1 - 12 inches

D2 Intended depth of piezo

Pre-Assembly

1. Lay out the piezometers, lengths of placement pipe, and couplings.

2. Prepare cable ends with tape. Consider using different color tape for each cable to provide a secondary way to identify sensors if the serial number labels are damaged.

3. Push the cable upwards through the adjoining pipe and next multi-level housing.

4. Each housing adds another cable. Tape the cables together for easier pushing or pulling. In the photo at right, three cables are taped together for easier pulling or pushing.

5. Repeat steps 3 and 4 until cables have been threaded through all the pipe lengths, couplings, and piezometer housings.

6. Consider cementing one pipe onto each piezometer housing to ease handling later.

Installing

1. Stack the partially assembled piezometers near the borehole. The photo below shows pipe from a different instrument. You can see that cables are threaded through the pipe sections, and pipes are arranged for easy installation.

Different instrument, same concept: pipes are arranged for easy installation

2. Connect a safety line to the bottom piezometer. If you are using a flexible external grout pipe, attach it to the bottom pipe.

3. Position the piezometer and pipe over the borehole. Remove the filter (knurled ring) from the piezometer, fill the cavity with clean water, and replace the filter.

Filter

4. Insert the first piezometer into the borehole. Clamp the pipe at the top of the borehole so you can add pipe or the next piezometer.

5. Continue assembling the system, gluing all joints and filling the filter cavity with water. Repeat these steps until you place the final piezometer.
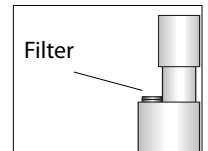
Grouting

Backfill the entire borehole with a bentonite-cement grout.

1. Pump the grout through the placement pipe or through an external grout pipe.

2. Keep grouting pressure below 700 kPa (100 psi), especially if you are using the optional grouting adaptor, shown at right.

3. Stop pumping when grout appears at the top of the borehole.

4. Cut off the excess pipe, being careful not to damage the cables.

5. Terminate the installation as specified. Be sure to protect the serial number labels on the ends of the cable.

Grout Recipes

Here are grout recipes. Read the notes below.

Grout Mix for Hard to Medium Soils

Materials	Weight	Ratio by Weight
Portland cement	94 lb (1 bag)	1
Water	30 gallons	2.5
Bentonite	25 lb (as required)	0.3

Grout Mix for Soft Soils

Materials	Weight	Ratio by Weight
Portland cement	94 lb (1 bag)	1
Water	75 gallons	6.6
Bentonite	39 lb (as required)	0.4

Read These Notes

- Mix cement with water first. Then add the bentonite to produce a grout with the consistency of heavy cream. If you add bentonite first, the mix will be too thick when cement is added. To thin the mix, you'll have to add water. This increases permeability, which is not desirable in this application. It also increases the risk of a flash-set. So mix cement with water first, and then add bentonite.

- There is no exact quantity of bentonite needed. The amount will vary with the bentonite itself, the method of mixing, and the pH of the water. If you have a Marsh funnel, the Marsh number of the liquid grout should be about 55 seconds.

Taking Readings

Introduction
Drilling and backfilling a borehole temporarily changes the pore-water pressure in the ground. In the case of multi-level piezometers, some time is required for the grout to cure. Wait for the natural pore-water pressure to recover before taking initial readings.

Recovery of the natural pore-water pressure may take a day or longer, depending on the permeability of the soil. Recovery is signaled by stable readings over a period of a few days.

VW Data Recorder
1. Connect signal cable to the data recorder.

Binding Posts	Possible Wire Colors	
VW	Orange	Red
VW	White & Orange	Black
TEMP	Blue	White
TEMP	White & Blue	Green
SHIELD	Shield	Shield

2. Choose Hz + RTD or Hz + Thermistor.

3. Select the 1400-3500 Hz range.

4. The recorder displays a pressure reading in Hz and a temperature reading in degrees C.

Retired Readouts
Manuals for retired readouts are available from the Slope Indicator website.

Data Loggers
- Instructions the VW MiniLogger can be found in the VW MiniLogger manual, available on the Slope Indicator web site.
- Instructions for Campbell Scientific data loggers can be found in the Tech Notes section of the Slope Indicator web site.

Data Reduction

Calibration Record

Each VW piezometer has a serial number and a unique calibration.

Serial Number

The serial number is found near the top of the page. Use the sensor serial number to match each sensor with its calibration record.

Calibration Factors

ABC Factors: These factors are used to convert Hz readings to units of pressure, such as kPa or psi. If only small changes in water temperature are expected, ABC factors, which offer no temperature correction, should work as well as TI factors.

TI Factors: These factors are also used to convert Hz readings to units of pressure, but use temperature readings from the built-in thermistor to provide temperature compensation. If the large changes in water temperature are expected, TI factors should provide better results.

Summary of Results

This table of recorded values shows the pressure applied by the calibration device, the frequency output of the sensor, and the pressure calculated by applying the calibration factors. It also shows error, the difference between the applied pressure and the calculated pressure, as a percent of the full range of the sensor.

Using ABC Factors

Apply ABC factors to convert Hz readings to units of pressure

$$Pressure = A \times Hz2 + B \times Hz + C$$

Where:
Hz is the frequency reading in Hertz
A, B, and C are ABC factors on the sensor calibration record

Using TI Factors

Apply TI factors to convert Hz readings to units of pressure.

$$Pressure = C0 + (C1 \times Hz) + (C2 \times T) + (C3 \times Hz^2) + C4 \times Hz \times T) + (C5 \times T^2)$$

Where:
Hz is the frequency reading in Hertz,
T is the temperature in degrees C from the built-in temperature sensor, and C0 through
C5 are TI factors on the sensor calibration record.

Calculating Changes

To calculate changes in pressure, subtract the initial reading from the current reading. A positive value indicates increased pressure. A negative reading indicates decreased pressure.

$$\Delta Pressure = Pressure_{current} - Pressure_{initial}$$

Acceptance Tests

Introduction The main purpose of an acceptance test is to provide reasonable assurance that a sensor is functioning properly.

The piezometer is shipped in protective foam and signal cable is coiled and tied. When you receive the piezometer, bring it indoors or move it into the shade and allow a few hours for it to reach ambient temperature. There is no need to remove the foam or untie the cable.

Operational
Check

1. Connect the end of the signal cable to your readout and take a reading. Check that the reading is stable. You now know that the piezometer is operational.

2. Note the serial number, Hz reading, the temperature, and the barometric pressure at the time of the reading.

3. The Hz reading should be relatively close to the zero reading on the calibration record. Higher altitudes or higher temperatures than those at calibration will cause the reading to be lower than on the calibration record.

Zero Check

1. Let the piezometer adjust to ambient temperature. Do not handle the piezometer body during the test.

2. Connect the signal cable to readout and obtain a frequency reading. Check that you have obtained a repeatable reading.

3. Apply calibration factors to convert the frequency to a pressure reading in psi.

4. If your local elevation is above sea level, the pressure reading that you obtain will most likely be negative because the sensor calibration is referenced to one standard atmosphere (sea level). To calculate a correction for your elevation, allowing 0.5 psi for every 1,000 feet of elevation above sea level (1.15 mb per 10 m). Add the correction to your reading. For example, if you are at 5,000 feet, you would add a correction of 2.5 psi to the pressure reading. (See the chapter on data reduction for more details). To make a more precise check, you would correct for the exact altitude, the barometric pressure, and the temperature.

5. The piezometer is working satisfactorily if the difference between the corrected pressure and zero is within 2 percent of the full scale of the piezometer (2 psi for a 100 psi piezometer).

Diagnostics

Introduction   Perform the tests below to diagnose what is wrong with your piezometer. Unfortunately, after the instrument has been installed, there is rarely any remedial action possible.

No Reading   Set your handheld multi meter to a low-ohm range (5k ohm).

- Measure the resistance between the two VW wires (orange and white-and-orange). A normal reading should be about 300 ohms. If the reading is very high or infinite, the coil is damaged (or the cable is severed). If the reading is very low, the cable may have been crushed and a short has developed.

- Measure the resistance between the temperature sensor wires (blue and white). Thermistors should read about 3000 ohms. RTDs should read about 2000 ohms. If the reading is very high or infinite, the temperature device is damaged (or the cable is severed). If the reading is very low, the cable may have been crushed and a short has developed.

Unstable Reading   Set your handheld multimeter to a high range (10 or 20 M ohm).

- Measure the resistance between a VW wire and a Temp wire. The reading should be infinite or out of range.

- Measure the resistance between any of the colored wires and the drain (shield) wire. The reading should be infinite or out of range.

- Measure the resistance between the shield wires of two installed VW sensors. Wires must be disconnected from data logger or terminal box to make this test. The reading should be very high or infinite. A lower reading indicates the presence of a ground loop.

- Other sources of unstable readings are electrical noise from nearby power lines, radio transmitters, or motors. Also, over ranged or shocked instruments can exhibit this problem.