

# Grouting-in Piezometers

## Introduction

A growing number of geotechnical engineers are choosing a faster, easier way to install piezometers: they omit the conventional sand intake zone and the bentonite seal. Instead, they simply place the piezometer and backfill the entire borehole with a non-shrinking, low-permeability grout.



The grout must have a permeability that is lower than that of the surrounding ground, so that it prevents a flow of water through the borehole, much like the traditional bentonite seal.

## The Theory

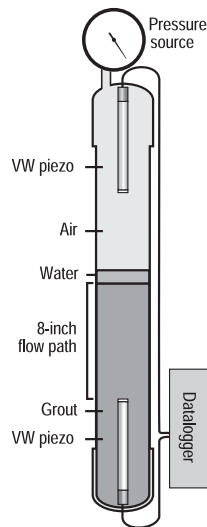
How can a piezometer operate when it is sealed in grout? Gordon McKenna, an early advocate of the method, explains it this way: “The key to the success of the grouted-in installation method is that modern diaphragm-type piezometer tips require only a very small fluid volume change for pressure equalization, and the grout can transmit this volume over the short distance from the formation to the tip quickly.” (McKenna, 1994)

Some numbers help illustrate this fact. Suppose there is a one psi increase in water pressure in the formation. With a 3/4-inch standpipe, it would take an inflow of 240 ml of water before this change could be measured. However, with a VW piezometer, the same change could be measured with an inflow of only 0.00002 ml, approximately 12 million times less. The mechanism that produces this tiny volume of water is more of a molecular migration than it is a flow.

## The Test

Erik Mikkelsen at Slope Indicator wanted to install piezometers along with inclinometer casing. To determine if this were feasible, he designed a test to measure the response time of a grouted-in piezometer.

Equipment used in the test included a pressure chamber, a regulated pressure source, two VW piezometers, and a data logger. One piezometer was installed, filter-end up, in the bottom half of the pressure chamber. A fold of geotextile material was strapped over the filter. Water was poured into the chamber so that the piezometer was submerged and the filter area could be saturated. Then grout was tremied to the bottom of the chamber and its level



was raised until it was eight inches above the filter tip of the piezometer. Eight inches was judged to be the maximum thickness of the grout backfill surrounding inclinometer casing.

A one-inch layer of water was left on top of the grout. The other piezometer and the fittings for the pressure source were installed in the top half of the chamber. The top

half was then sealed to the bottom half, and a 5 psi pressure was applied and maintained to simulate a confining pressure.

The grout mixture used in the test was the same mix that Slope Indicator recommends for inclinometer casing.

Material	Weight	Weight Ratio
Portland cement	94 lb (1 bag)	1
Bentonite	25 lb	0.3
Water	30 gallons	2.5

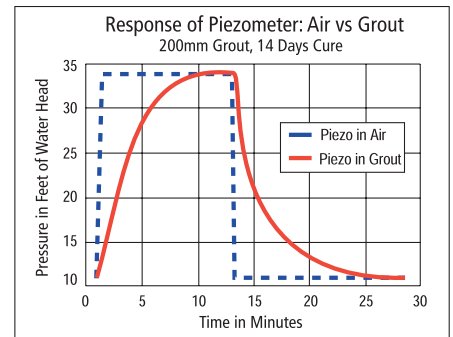


## The Test Procedure

Tests were run on day 2, 7, 14, and 30. In each test, pressure in the upper chamber was increased by 10 psi. The datalogger then recorded readings until both piezometers showed 100% response to the applied pressure. Afterwards, pressure was returned to the constant 5 psi confining pressure.

## The First Series of Tests

The plot below shows the results from a typical test in the first series. The piezometer in air responds instantly to the increase in pressure, while the piezometer in grout responds more slowly.



The time-lag for 100% response of the grouted-in piezometer increased as the grout cured. Results are shown in the table below:

Curing Days	7	14	21	30
Time Lag (minutes)	3	10	14	18

## The Second Series of Tests

The second series of tests was run for 280 days. In this series, the geotextile protection for the filter was eliminated. This dramatically shortened response times. We believe that air trapped in the geotextile slowed response time in the

first series. While response time still increases with curing days, the time-lag at 30 days is only 2.4 minutes. At 90 days, the response-time curve flattens, and at 128 days, the response time stabilizes at about 3.5 minutes.

### Discussion

These tests verify that a diaphragm piezometer operates properly without a sand intake zone and that when installed directly in a bentonite-cement grout, the piezometer shows only a very short delay in response to changes in pressure.

The practical implications are that installation procedures for piezometers can be simplified and that no special protection or grout mixture is required for piezometers installed with inclinometer casing.

A further implication, as demonstrated in the reference papers listed below, is that the grout-in method provides an easy way to install multiple piezometers in the same borehole.

### References

McKenna, G.T, "Grouted-in Installation of Piezometers in Boreholes, Geotechnical Journal 32, pp 355-363, 1995. The quote is from a 1994 paper with the same name. Also, Vaughan, P.R, "A Note on Sealing Piezometers in Boreholes," Geotechnique 19, No 3, pp 405-413, 1969.

