



INSTRUCTION MANUAL

PNEUMATIC PORE WATER PRESSURE CELL

FPC-2 Model

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This product should be installed and operated only by qualified personnel. Its misuse is potentially dangerous. The Company makes no warranty as to the information furnished in this manual and assumes no liability for damages resulting from the installation or use of this product. The information herein is subject to change without notification.

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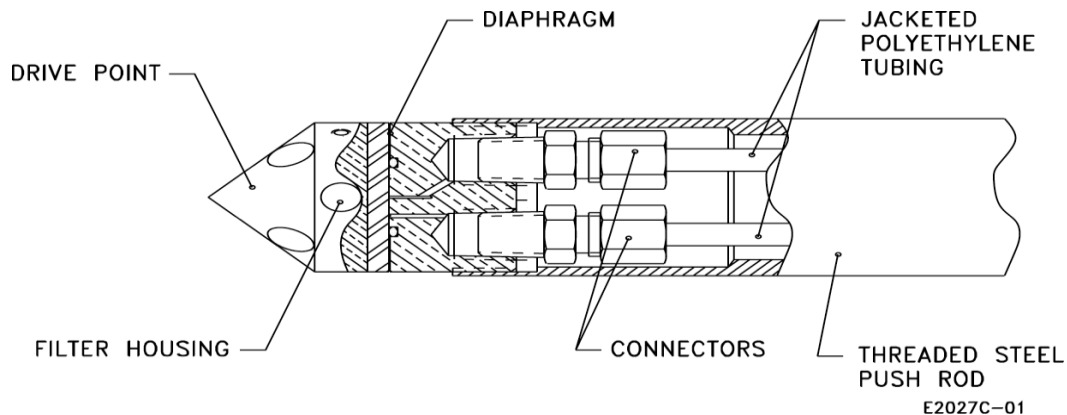
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1 DESCRIPTION

The FPC-2 pneumatic piezometer is designed to measure fluid pressure in soil and rock masses, and at the interfaces or in the vicinity of structures buried in the ground. It is used to monitor pore-water or joint-water pressure in embankments and backfill, dams, foundations natural and cut slopes, excavations, etc.

The cylindrically-shaped FPC-2 piezometer is fitted with a filter at its base and two pneumatic-tubing fittings to connect the nitrogen gas input and return lines.

The FPC-2 comprises a thin flexible diaphragm on which is applied the fluid pressure. During readout this pressure is balanced by an externally applied nitrogen gas pressure. The readings are obtained when the external gas pressure is equal to the pore-water pressure acting on the reverse side of the diaphragm. The volume change associated with pressurization of the diaphragm is extremely small and consequently the response time is very low, even in low permeability soils as clays.



Model FPC-2D Pneumatic Piezometer

The design and the materials (stainless steel or brass) used in the construction of the FPC-2 make it particularly suitable for use in both short and long term monitoring programs where ruggedness, stability and reliability are required. An integrated filter on the input gas line prevents the entry of foreign particles into the piezometer.

The accurate measurement of pore water pressure requires:

- the measuring system utilized (in the transducer) should not provoke a large volume change at the measuring point; that is the diaphragm displacement should be minimized and the transducer must be well saturated.
- the material used in the spatial environment adjacent to the transducer be compacted to the same degree as the surrounding material.

2 SPECIFICATIONS

Model:	FPC-2	FPC-2D	
Measuring range (F.S.):	0 - 1000 kPa (standard) 0 - 3500 kPa (high pressure)		
Accuracy:			
- PR-20 readout:	±0.25% F.S. of pressure gage		
- PR-20D readout:	±0.25% F.S. of pressure transducer		
Diaphragm volumetric displacement:	< 0.01 cm ³		
Standard construction:	Brass		
- Optional:	Stainless steel		
Filter:	Pore diameter	Air-entry coefficient	Permeability
- Bronze, stainless steel, plastic:	50 mm	10 kPa	10 ⁻⁴ cm/s
- Ceramic:	0.6 mm	450 kPa	10 ⁻⁸ cm/s
Twin tubing:	2 polyethylene tubes (ID: 2.5 mm, OD: 4.7 mm) under a PVC jacket		
- Optional:	2 nylon 11 tubes (ID: 3.2 mm, OD: 6.3 mm) under a polyethylene jacket		
Dimensions of piezometers:			
- Outside diameter:	32 mm	32 mm	
- Length:	28 mm	52 mm	

3 INSTALLATION OF THE PIEZOMETER

The FPC piezometer should be installed in such a manner that the environment in which it is installed be returned to its initial degree of compaction and as far as possible with the same material. Filling of the borehole in which the piezometer is installed should be done in lifts not exceeding 4 inches. The lifts should be compacted as the filling proceeds.

The piezometer should be monitored during the back filling to follow the evolution of the pressure. Should the hole be cased, the casing should be removed as the hole is filled. The material used to backfill the hole may vary, but must be less permeable than the original or host material in which the borehole was drilled.

3.1 SATURATING THE PIEZOMETER

The space between the outer boundary of the porous filter and the diaphragm must be completely filled with bubble free water having a low surface tension. This solution is prepared by adding one drop of liquid soap to 1 liter of clean water. If available, de-aired water can be used. The saturation is carried out immediately prior to placing the transducer in place. If carried out beforehand, the saturated transducer with the lead tubing's attached, must be kept submerged in a container of water.

To saturate the FPC piezometer, you just need to submerge the piezometer in a container of water.

The piezometer should be held at 45° with the filter in the upper position and should be slowly lowered in the water.

3.2 INSTALLATION IN FILL

3.2.1 COMPACTED CLAY

Excavate a trench or recess about twenty inches deep by two to three feet square. Form a cylindrical hole in the sidewall of the trench. The borehole diameter should be slightly smaller than the piezometer's body.

Push the piezometer into the side of the hole. Make sure that the piezometer filter is in direct contact with the host material. If necessary to ensure continuity with the saturated high air entry filter and the pore water, smear the filter with a thin paste of the saturated material.

Before backfilling, the tubing must be laid with the utmost care. Loop the tubing around the recess, making sure it rests on a bed of hand placed and compacted screened clay.

Make sure that the tubing does not cross over itself or other tubing in the same area.

Backfill the recess with screened clay containing no particles larger than .1 inch in diameter. The backfill should have a water content and density equal to that of the surrounding material.

Make sure the tubing is protected from potential damage caused by angular material, compacting equipment or stretching due to subsequent deformations during construction or fill placement.

3.2.2 GRANULAR MATERIAL

Install the piezometer as described above in a recess excavated for this purpose. Place the piezometer within the trench, loop tubing and backfill with screened material containing the same moisture content and compacted to the same density as the surrounding fill. In rock fill, it is necessary to place a graded filter around the piezometer. Use fine grain clean sand around the instrument and increase the particle size as the backfill proceeds outwards to the rock fill. The sand placed in the recess around the instrument and tubing should range in size from .02 to .1 inches in diameter.

3.2.3 INSTALLATION IN BOREHOLES

The method used to install a piezometer in a borehole depends on the particular conditions in which the installation must be carried out. The method described below will cover most applications. Artesian conditions, borehole stability, available drilling equipment and sealing materials are among the factors, which will influence the method chosen.

The casing is driven one foot below the required piezometer elevation. If the piezometer is to measure the pore water pressure in a specific horizon, it will be necessary to drive the casing three feet below the piezometer elevation to enable the placement of a bentonite pellet seal at the bottom of borehole.

After driving the casing, wash until the water emerging from the hole runs clear.

If required, set the two-foot bentonite seal at the bottom of the borehole. Raise the casing six inches. Place the bentonite in six-inch increments until the bentonite level is one foot below the piezometer elevation. Pull the casing as the bentonite is set in place. Be very careful not to plug or allow bentonite to stick to the inside walls of the casing. This is accomplished by making sure the bentonite level is at all times below the casing and by **slowly** dropping the bentonite pellets in single file down the hole. Trying to feed the bentonite pellets too rapidly will result in bridging of the pellets in the casing or borehole. This will make it extremely difficult to complete the seal. Tamping of compressed bentonite pellets is not required.

Prior to setting the sand in place, lower a cylindrical weight down the hole to ensure that the hole is clear from any obstructions and if necessary, rinse the borehole until clear water emerges.

In the same manner, place twelve inches of fine, clean sand in six-inch increments below the level of the piezometer tip. Pull the casing as the backfilling with the sand proceeds. Lower the piezometer into the hole. Take the initial readings as described above.

Pull the casing six inches and backfill with fine clean sand. Repeat until the sand and the casing are one foot above the top of the piezometer. Take another reading on the piezometer.

Lift the casing in six-inch increments and backfill with bentonite pellets until a minimum four-foot seal has been formed. During the bentonite pellet placement keep the tubing taut to prevent the pellets from hooking up in the casing. Pour the pellets in the hole one at a time to avoid bridging. If only one piezometer is to be installed in the hole, backfill the casing with a cement/bentonite grout. If more than one piezometer is to be installed in the hole, backfill with host material or sand/bentonite mixture to an elevation of 4' below the second piezometer, then use 3' of bentonite, 1' of sand, then the piezometer. Proceed as described above.

Pull the casing. Do not rotate the casing during removal.

Once all casing is removed, top off the borehole with grout.

3.3 INSTALLATION OF DRIVABLE FPC-2D PIEZOMETER

The model FPC-2D is designed to be pushed into place from the surface in soft materials. For deeper installations where driving from the surface is impossible, the piezometer may be pushed into place from the bottom of a pre-drilled borehole.

The FPC-2D drivable piezometer comes with a threaded connecting rod of 1.3" O.D., that is to say slightly larger than the piezometer's diameter. This connecting rod ensures a good contact with the soil above the piezometer. The standard length of this connecting rod is 2 feet. The twin tubing is connected to the piezometer and then threaded through the connecting rod. The connecting rod is then screwed on the piezometer after application of a few drops of sealing fluid to ensure a good watertightness.

The rods form an effective seal above the piezometer. Should other rods be adapted to push the piezometer in place it is important that the diameter of the first four to five feet of rod remains larger than the outside diameter of the FPC-2D piezometer housing.

The first step is to lay a sufficient number of rods side by side, alternating a male thread beside a female thread.

The piezometer tubing is threaded through the rods leaving a one to two foot loop of tubing laying flat on the ground each time the tubing emerges from one rod and enters a subsequent rod.

Let a twenty to twenty-five foot length of free tubing extend beyond the lower extremity of the first rod. This (for ten-foot rod lengths) should provide sufficient slack to allow easy manipulation of the rods as they are screwed together and pushed in place.

To saturate the piezometer, follow the same procedure as for the FPC-2 (described in section 3 of this manual). If the first rod is already screwed on the FPC-2D housing and prevent the piezometer from being submerged in an upward position, a water-filled syringe can be used by placing it against the bottom filter (while holding the piezometer horizontally) and forcing water into the piezometer. Once the piezometer is fully saturated, wrap it in a plastic bag until it is ready to be driven in.

WARNING: DO NOT REMOVE THE FOUR SCREWS FROM THE PIEZOMETER TIP, SINCE THIS WILL COMPLETELY DISASSEMBLE THE PIEZOMETER AND MAY DAMAGE INTERNAL COMPONENTS.

Screw the lower rod onto the piezometer. Use a pipe sealing compound on the threads to form a permanent seal, preventing pore water from flowing into the rod string, causing corresponding pressure drops.

WARNING: TO PREVENT EXCEEDING PRESSURE LIMIT, CONNECT FPC-2D PIEZOMETER TO A READOUT UNIT WHILE PUSHING THE PIEZOMETER IN THE GROUND.

Push the piezometer in place and monitor any pressure build-up at the tip. Should the pressure exceed the working pressure range, stop the driving and wait until the pressure dissipates.

In soils with high salt content it is necessary to use a nylon bushing between the FPC-2D piezometer and the push rods to prevent apparent pore water pressure increases caused by hydrogen gas generation due to galvanic corrosion, or pressure increases caused by any electro-osmotic effect on the pore water.

4 MISCELLANEOUS

4.1 INSTRUCTION FOR POTTING THE FPC-2

- 1 Cut the ends of the jacketed twin-tubing square.
- 2 Remove two inches of outer black jacket from the end of the tubing. Be careful not to cut the tubing when removing the jacket.
- 3 Slide the PVC tubing mold over the end of the twin tubing.
- 4 Connect the white tubing to the input (I) and the black tubing to the output (O).
- 5 Push the tubing mold onto the FPC-2 piezometer. Wrap two layers of PVC electrical tape around the joint.
- 6 Mix the potting compound as follow:
 - Component A: 4 parts by volume
 - Component B: 1 part by volume
- 7 Stir the mixture well (2 minutes) and pour the compound into the PVC mold. Let harden for 24 hours.
- 8 Remove 6 inches of black jacket from the other extremity of the twin tubing.
- 9 Connect the male (stem) quick connect to the white input line.
- 10 Connect the tubing cap to the black line.

4.2 NOTES ON THE TPC PNEUMATIC PRESSURE TRANSDUCER

As for a vibrating wire pressure cell, an initial reading in laboratory needs to be taken to take account of the reload value of the cell. This value is the pressure required at atmospheric pressure and no load condition on the pad, to actuate the diaphragm allowing the air feed to escape through the return line. This value may vary from a cell to another, due to the saturation pressure of the pad in our shops. This value is low and will generally vary from 0.5 to 1.5 kg/cm².

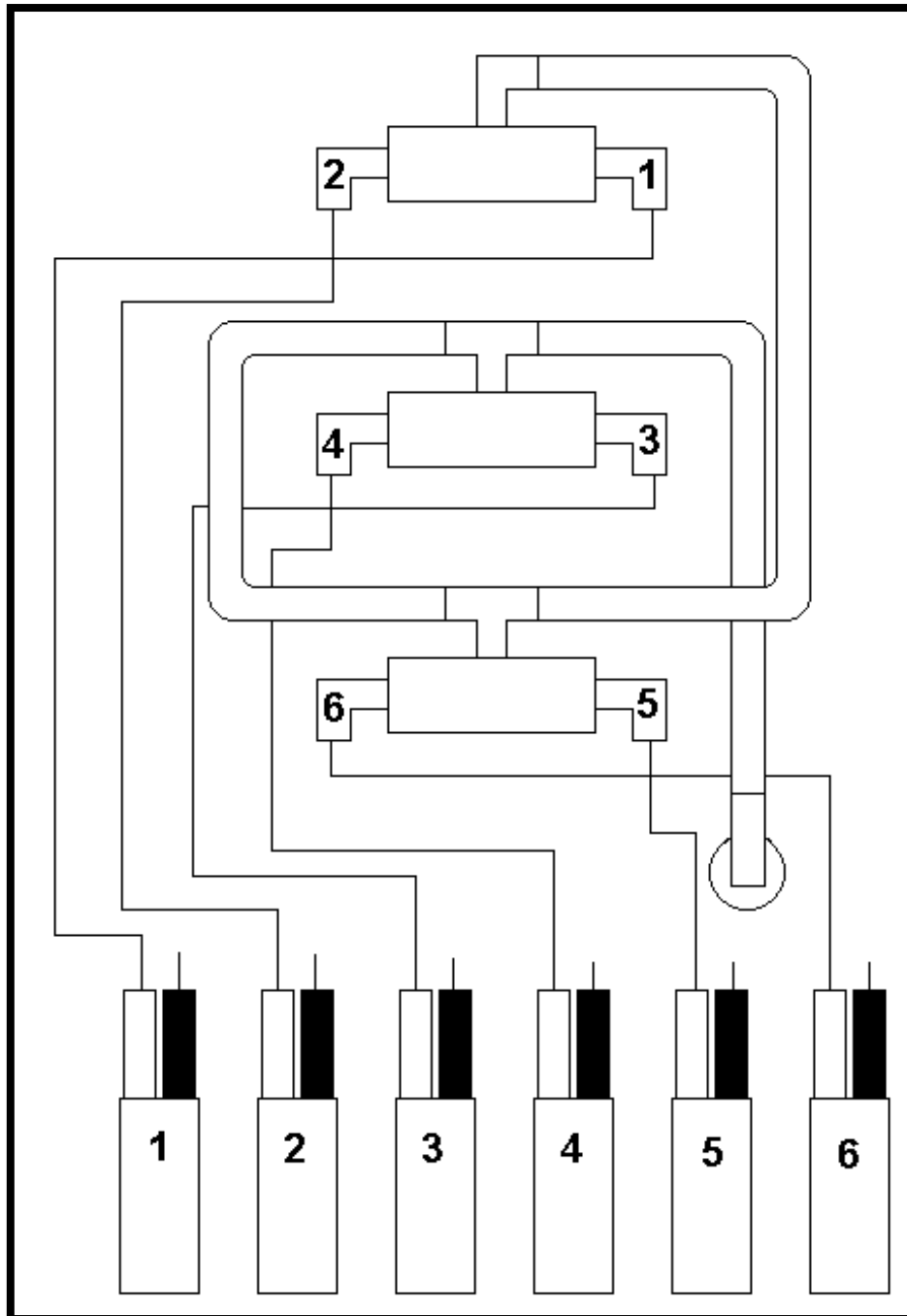
4.3 CONVERSION FACTORS

LENGTH	Microns	Inches	3.94E-05
	Millimeters	Inches	0.0394
	Meters	Feet	3.2808
AREA	Square millimeters	Square inches	0.0016
	Square meters	Square feet	10.7643
VOLUME	Cubic centimeters	Cubic inches	0.06101
	Cubic meters	Cubic feet	35.3357
	Liters	U.S. gallon	0.26420
	Liters	Can-Br gallon	0.21997
MASS	Kilograms	Pounds	2.20459
	Kilograms	Short tons	0.00110
	Kilograms	Long tons	0.00098
FORCE	Newtons	Pounds-force	0.22482
	Newtons	Kilograms-force	0.10197
	Newtons	Kips	0.00023
PRESSURE AND STRESS	Kilopascals	Psi	0.14503
	Bars	Psi	14.4928
	Inches head of water*	Psi	0.03606
	Inches head of Hg	Psi	0.49116
	Pascal	Newton / square meter	1
	Kilopascals	Atmospheres	0.00987
	Kilopascals	Bars	0.01
Kilopascals	Meters head of water*	0.10199	
TEMPERATURE	Temp. in °F = (1.8 x Temp. in °C) + 32		
	Temp. in °C = (Temp. in °F - 32) / 1.8		

* at 4 °C

E6TabConv-990505

4.4 OPTIONAL JUNCTION BOX



WIRING DIAGRAM FOR FPC-2 PIEZOMETER JUNCTION BOX

1. Remove the quick connectors from the white tubings and the caps from the

- black tubings.
2. Remove the front plate from the junction box by removing the four screws located at each corner.
 3. Connect the white tubings on the corresponding ports of the valve.
 4. Keep the black tubings open.
 5. Screw the front plate back in place.

4.5 REFERENCES

- A-1 Terzaghi, K and Peck, R. B.; "Soil Mechanics in Engineering Practice", John Wiley and Sons, Inc., 1967. (Article 68 of Chapter 12 provides a survey of tip types and recommendations on installation procedure.)
- A-2 U. S. Department of the Interior, Bureau of Reclamation; "Earth Manual", U. S. Government Printing Office, Washington 1974. (Designations E-27 and E-28 in the Appendix give detailed guidance on piezometer installations in dam foundations.)
- A-3 Bishop, A. W., Vaughan, P. R., and Green, G. E. (1969); Report on specialty session, "Pore Measurements in the Field and in the Laboratory", Proc. 7th, Int. Conf. Soil Mech. and Found. Eng. 3, 427. (A review of recent practice and instrumentation, related principally to earth structures.)
- A-4 "Suggested Methods for Determining In-Situ Permeability, Groundwater Pressure and Flow"; Int. Soc. for Rock Mechanics, Committee on Field Tests (Draft report, 1974; Final report in course of preparation.)
- A-5 Hanna, T.H.; "Foundation Instrumentation", Trans. Tech. Publications, Ohio, USA, 1973. (Chapter 3 describes different types of piezometer tip, methods of installation, methods of recording and the protection of piezometer.)
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- A-8 Baker, C. (1978); "Surge Protection for Instrumentation", proceedings of the Tempcon Conference, London. Available from Measurement Technology, Inc., 7541 Gary Road, Manassas, Virginia, 22110, U.S.A.
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