Version 1.4 May 09

VW PIEZOMETERS

INSTRUCTION MANUAL

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1.0 INTRODUCTION

This manual is intended for all users of Vibrating Wire Piezometers manufactured by MGS Geosense and provides information on their installation, operation and maintenance**.**

It is VITAL that personnel responsible for the installation and use of the piezometers READ and UNDERSTAND the manual, prior to working with the equipment.

1.1 General Description

The **Vibrating Wire Piezometer** is an environmentally sealed sensor that is used to register changes in fluid pressure, generally in, but not limited to, under ground locations.

A Vibrating Wire Piezometer can be installed or included in many types of monitoring regime and can be linked to various types of readout equipment.

The primary uses for piezometers are :-

Soil and rock pore pressure measurement.
Water level monitoring (groundwater or open chambers)

With applications such as, but not limited to, the following :-

Embankment stability and safety monitoring
Measuring loads behind retaining walls
Assessing soil consolidation
Measurement of uplift pressures acting on structural foundations
Verification of seepage patterns and models
Slope stability monitoring
Water level monitoring for Environmental control
Tidal influence assessment
Pump Testing

Particular features of the MGS-Geosense piezometer are:-

Reliable long term performance.
Rugged; suitable for demanding environments.
High accuracy.
Insensitive to long cable lengths.

The Piezometer is based upon 'industry standard' Vibrating Wire technology. When electronically excited, the sensor produces an output signal in the form of an alternating current. The frequency of the alternating current can then be readily converted to a fluid pressure by applying individual calibration factors.

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Frequency signals are particularly suitable for the demanding environment of civil engineering applications, since the signals are capable of long transmission distances without degradation. They are also somewhat tolerant of damp wiring conditions and resistant to interference from external electrical noise.

The MGS-Geosense range of VW piezometers is supplied in various configurations to suit varying installation environments and techniques. Each VW piezometer is fitted with a length of connecting cable, an internal temperature sensor and a surge arrestor. Each VW piezometer option is detailed in this manual, with its own specific installation instructions.

1.2 Theory of Operation

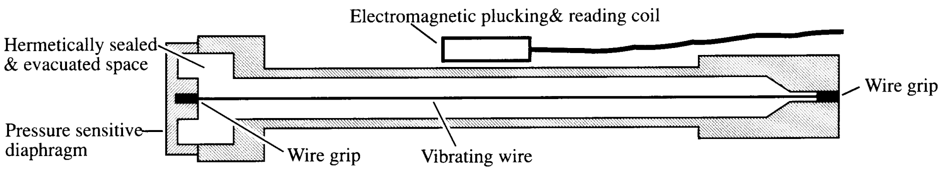
The Vibrating Wire Piezometer consists of a tensioned steel wire, anchored at one end to a flexible diaphragm (the sensing element) and at the other end to the Nimonic inner body, all sealed into a stainless steel body. The internal parts of all MGS Geosense piezometers are identical, only the thickness of the diaphragm and the geometry of the body changes.

Two opposing coils are located within the inner Nimonic body close to the axis of the wire. When a brief voltage excitation, or swept frequency excitation is applied to the coils, a magnetic field is induced causing the wire to oscillate at its' resonant frequency. The wire continues to oscillate for a short period through the 'field' of the permanent magnet, thus generating an alternating current (sinusoidal) output. The frequency of this current output is detected and processed by a vibrating wire readout unit, or by a data logger equipped with a vibrating wire interface, where it can be converted into 'Engineering' units of pressure.

As fluid pressure is applied to the exposed side of the flexible diaphragm, the diaphragm deflects, causing a change in the tension of the wire behind it. The change in tension of the wire results in a change in resonant frequency of oscillation of the wire, with the square of frequency of oscillation being directly proportional to the applied pressure.

For further information see Section 6 - Data Handling.

Transducer Schematic



2.0 CONFORMITY

Marton Geotechnical Services Ltd
Geotechnical Centre
Rougham Industrial Estate
Rougham, Bury St Edmunds
Email: info@mgs.co.uk, Web: www.mgs.co.uk.

Declaration of Conformity

Document Number QF037 (Iss 2)

We Marton Geotechnical Services Ltd at above address declare under our sole responsibility that the Geosense products detailed below to which this declaration relates complies with protection requirements of the following harmonized EU Directives,

Low Voltage Directive 73/23/EEC (as amended by 93/68/EEC)
The Electromagnetic Compatibility Directive 2004/108/EC
The Construction Products Directive 89/106/EEC

Equipment description	**Vibrating Wire Piezometers**
Make/Brand	**Geosense**
Model Numbers	**VWP-3000, VWP-3001, VWP-3101, VWP-3200** **VWP3201, VWP-3300, VWP-3400**

This equipment has been designed and manufactured with reference to the following standards:

All mechanical drawings used in the production of this equipment are based upon BS 8888
Electrical/electronic drawings are based upon BS 3939.

A technical file for this equipment is retained at the above address
This Declaration of Conformity was prepared according to EN ISO/IEC 17050-1:2004.

Martin Clegg
Director

3.0 MARKINGS

Geosense piezometers are labelled with the following information:-

Manufacturers name & address

Product type

Model

Serial number

CE mark

4.0 DELIVERY

This section should be read by all users of Vibrating Wire Piezometers manufactured by MGS Geosense.

4.1 Packaging

VW Piezometers are packed for transportation to site. Packaging is suitably robust to allow normal handling by transportation companies. Inappropriate handling techniques may cause damage to the packaging and the enclosed equipment. The packaging should be carefully inspected upon delivery and any damage MUST be reported to both the transportation company and MGS Geosense.

4.2 Handling

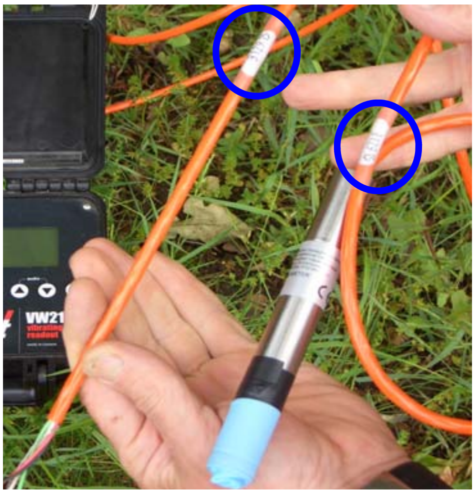
Whilst they are a robust devices, VW piezometers are precision measuring instruments. They and their associated equipment should always be handled with care during transportation, storage and installation.

Once the shipment has been inspected (see below), it is recommended that piezometers remain in their original packaging for storage or transportation.

Cable should also be handled with care. Do not allow it to be damaged by sharp edges, rocks for example, and do not exert force on the cable as this my damage the internal conductors and could render the installation useless.

4.3 Inspection

It is important to check all the equipment in the shipment as soon as possible after taking delivery and well before installation is to be carried out. Check that all the components detailed on the documents are included in the shipment. Check that the equipment has not been physically damaged.



ALL Geosense VW piezometers carry a **unique** identification serial number which is located on the cable close to the piezometer body and at the free end of the cable (see right). All VW piezometers are supplied with individual calibration sheets that include their serial numbers and these will shipped with the piezometers.

Calibration Sheets contain VITAL information about the piezometer. They MUST be stored in a safe place. Only

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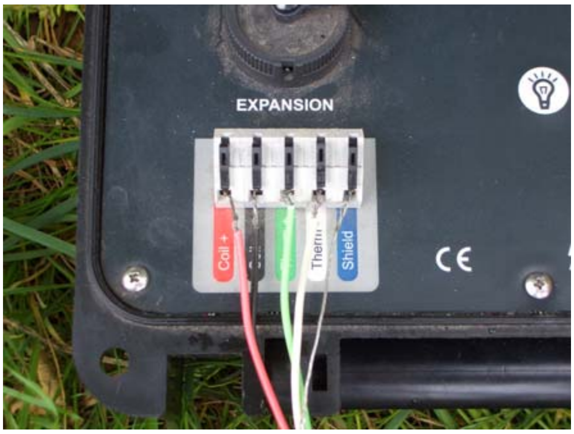

copies should be taken to site.
CHECK the piezometer 'Zero Readings' against the factory 'Zero Readings' on arrival to ensure they have not changed due to damage during transportation. To do this, connect a Vibrating Wire readout to the bare cable ends (Black and Red conductors). – See readout manual for connection guidance.

NB If the readout display is in 'Period' units (eg 0.03612) a calculation must be performed to convert to Hz²/1000 (Linear Digits) units, since the calibration sheet is presented in Hz²/1000 units. The Geosense Readout model **VW200 displays the readings in 'Period'. The RST readout / logger unit Model Number* **VW2106** *displays the readings in Linear digits. See Section 6 of this manual for more information on units and conversion routines.*

Prior to carrying out a 'Zero Reading' CHECK, ensure that the piezometers have been stored in a reasonably stable temperature for at least 30– 60 minutes.

Record the values displayed on the readout (and units) against the piezometer serial numbers. If these 'out of the box' CHECK readings show significant differences (+/- 40 digits) to the zero pressure values on the calibration sheets, contact MGS Geosense for assistance. (It should be noted that the 'CHECK Readings WILL be affected by the atmospheric pressure & altitude).

If components are missing or damaged, contact the delivery company, the supplier and / or MGS Geosense.

4.4 Storage

All equipment should be stored in an environment that is protected from direct sunlight. It is recommended that cables be stored in a dry environment to prevent moisture migrating along inside them in the event of prolonged submersion of exposed conductors.

During operational checks and establishing zero values, it will be necessary to submerge the VW piezometers. Subsequent exposure to sub-zero temperatures

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may cause damage to the diaphragms if the water they contain is allowed to freeze.

Storage areas should be free from rodents as they have been known to damage connecting cables.

No other special requirements are needed for medium or long-term storage although temperature limits should be considered when storing or transporting associated components, such as readout equipment.

5.0 INSTALLATION

This section of the manual is intended for all users of Vibrating Wire Piezometers manufactured by MGS Geosense and is intended to provide guidance with respect to their installation.

It must be remembered that no two installations will be the same and it is inevitable that some ‘fine tuning’ of the following procedures will be required to suit specific site conditions.

It is VITAL that personnel responsible for the installation and use of the piezometers READ and UNDERSTAND the manual, prior to working with the equipment.

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As stated before, it is vital to check all the equipment in the shipment soon after taking delivery and well before installation is to be carried out. Check that all components that are detailed on the shipping documents are included.

5.1 ZERO Pressure or BASE Readings

Vibrating wire transducers differ from most other pressure sensors in that they indicate a reading with no pressure applied. ZERO or BASE Readings can vary significantly between sensors.

It is, therefore, ESSENTIAL TO TAKE BASE READINGS
BEFORE
INSTALLATION.

As with all transducers, do not directly handle the piezometer body when recording the base readings, as this will cause local temperature gradients across the piezometer that will distort the readings.

Where piezometers are to be installed with their bodies orientated either horizontally or with their filters upwards, read the base readings in a similar orientation. (Low pressure transducers, in particular, can be very sensitive to orientation. Always obtain base readings with the sensor orientated in the same direction in which it will finally be installed.

The ‘on-site’ BASE readings for the Vibrating Wire Piezometer should be obtained as follows:

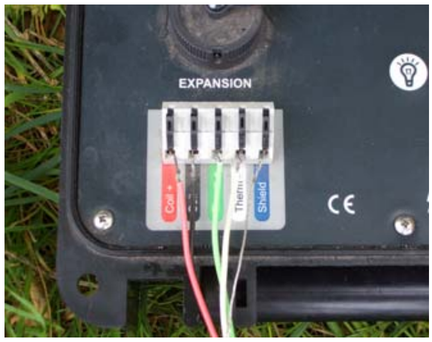
1. Fill a large bucket with clean, potable water, ideally of a temperature close to that of the groundwaterr temperature.

2. Ensure that the bucket is away from any heat sources and shaded from the sun. Stir the water occasionally to ensure an even temperature. Place the piezometer body in the bucket.

3. With the transducer submerged in the water, carefully remove the rubber sleeve from the piezometer.

4. With the transducer still submerged in the water, carefully remove the filter from the piezometer body by carefully twisting and pulling it, leaving both submerged in the water.

5. At the free end of the cable, connect the red and black leads to a vibrating wire readout unit and occasionally monitor the transducer output by turning on the readout and observing the display (see the readout user manual for assistance). After 10 or 20 readings, be sure to turn off the readout or disconnect the wire so as to avoid ‘heating’ the Vibrating Wire element.



6. Leave the transducer completely submerged in water for a minimum of 30-60 minutes and until the output of the transducer is unchanged over a period of 2-5 minutes.

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7. Turn on the readout. Holding the piezometer cable, lift the transducer out of the bucket, allowing it to hang vertically downwards and immediately record 2 or 3 readings. Replace the transducer in the water as before. After one minute of immersion, repeat and record another set of readings. Repeat three times, checking that the readings displayed are within +/- 0.5 digits of each other.

8. Record these readings together with the date and time.

9. Return the transducer to the water with the open end upwards, but submersed.

10. Obtain and record the barometric (atmospheric) pressure for future use. It is best to use a site based reading but a local metrological station may be used.

11. Locate the filter in the base of the bucket and having ensured that the void in the filter housing is completely filled with water, replace it onto the piezometer body.

12. **Take great care** with HAE (High resistance to Air Entry) filters. Allow the water pressure to dissipate through the filter by only applying a small amount of pressure to the filter body, leaving time for the water to pass through it.

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13. Store the piezometer in water until ready for installation (or repeat the above just prior to installation)

5.2 Preparation for Installation

Prior to installation of a piezometer it is essential to establish and confirm details of the installation to be carried out. Some of the main considerations are listed below :-

1. Intended elevation and depth to Piezometer?

   This can be calculated as either the depth below a known level (ground level for example) or as the elevation with respect to a remote datum. For borehole installations the final depth should be calculated and then the cable marked to show the intended installed position.

   For surface installations, a reference elevation can be created close to the final position of the piezometer.

2. Borehole Installation type / Specification

   Where a piezometer is to be installed in a borehole, is it to be pushed into the base of the borehole, installed in a filter pocket, grouted into the borehole without a filter or provided with a long filter for groundwater monitoring?

   The most common type of piezometer installation is the filter pocket type where the piezometer is used to register pressures from a specific sub-surface horizon or strata.

   The full length (or observation well) installation is probably the next most common. It simply allows groundwater from any horizon to flow into the borehole to be registered by the piezometer.

   Where a rapid response is required from a saturated material with a low permeability, the piezometer can be pushed into the undisturbed base of the borehole to provide an intimate connection to the pore water pressure in a particular horizon.

   Some engineers consider that a fully grouted borehole (using a Bentonite / Cement mixture) will allow the piezometer to detect and reflect the pore pressure equally well. In this installation, the piezometer (or string of piezometers) is suspended in the borehole and the borehole is backfilled with liquid grout from the base upwards. In some respects, this could be considered similar to the push-in type installation, where the grout mix reflects the permeability of the surrounding strata. This approach is particularly advantageous where more than one piezometer is to be installed in a single borehole.

3. Surface Installation type / Specification

   Where a piezometer is to be installed at surface level, is it to be pushed into a pre-formed cylindrical pocket or installed in a small excavated pocket? (These installations would normally be covered by fill material and often compacted

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mechanically).

In a location where high permeability material is present, a sand pocket type installation is preferred. Where a piezometer is to be installed in a material with a low permeability, it is normally better pushed into a pre-formed pocket to maintain intimate contact with the surrounding material. (Sand pockets should be avoided in low permeability surface installations, so as to reduce the presence of trapped air and therefore maintain an acceptable response time).

4. Filter zone

A specially graded sand (commonly 600 - 1200 μm) is the most common material used to provide a filter and borehole support for the piezometer tip. The volume of material required will depend upon the borehole diameter and the length of the filter zone to be formed. Typically a 1 metre zone is recommended or in accordance with project specifications.

(In some cases piezometers can be fitted inside small hessian bags that are then filled with filter sand. This creates a pre-formed filter pocket and adds weight to the assembly to help with borehole installation. The filter bag should be fitted in advance of installation, filled with sand and allowed to soak in a bucket of water prior to placing.)

5. Bentonite seal

Where a sealed pocket is to be formed for the piezometer, compressed and dehydrated Bentonite in the form of either pellets, balls, chips, etc is commonly used to form the seal. These are commercially available in bagged form or can be created on site using Bentonite powder and manual labour. (Man-made balls are only suitable for shallow boreholes with a diameter ≥ 100mm. This is because they are more difficult to use as they can break-up before reaching their intended elevation in deep boreholes).

Once in place, the Bentonite expands by absorbing water to form an impermeable borehole plug. In dry boreholes, water must be added to allow the Bentonite to swell. Normally a plug is only required above any filter pocket but a plug may also be used below a pocket, for example, where the borehole extends beyond a piezometer filter base elevation.

6. Cable marking.

Cables should be marked with unique identification. Markings should be repeated at regular intervals along the cable where multiple cables are to be grouped together, so that in the event of cable damage, there may be a chance that the identification could be exposed and the cables re-joined. Multiple cable marks are particularly important close to the end of the cable. The spacing of markings can vary according to specific site requirements but a guide of 5m to

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10m is commonly applied (available on request).

7. Tools.

Obtain any tools necessary to carry out the installation. The following is a brief list of tools typically used during the installation of Vibrating Wire Piezometers.

- **Fibre measuring tape** with a weight added to the end for borehole depth measurement and cable length measurement.
- **Shovel** for placing and levelling fill by hand
- **Wire cutters and strippers**
- **Vibrating Wire Readout unit** for checking the piezometer function
- **Cable Marking** system / equipment (eg coloured PVC Tapes)
- **Grout mixing and placing equipment**
- **PVC tape**

5.3 Installation Procedures - Boreholes

Each piezometer installation is different and requires both common sense and a general understanding of the sub-surface conditions. There are many approaches to piezometer installation and, in addition to these broad installation guidelines, MGS Geosense are committed to providing technical support to help engineers and technicians tune their procedures to match particular site conditions and requirements.

Boreholes can be flushed with clean water prior to installation operations if excessive sediment remains in suspension.

Each piezometer is labelled on the cable, however steps should be taken, perhaps with the aid of coloured tapes, to mark the cable so that there is no confusion over piezometer identification. This is particularly important for installations where more than one piezometer is to be installed in one location.

5.3.1 Cased boreholes.

When forming a borehole for instrument installation, it is sometimes necessary to use a temporary steel sleeve or 'casing' to hold the hole open during drilling and installation operations. The following describes a series of steps that could be adopted to carry out a piezometer installation in such a fully cased borehole. This procedure can be adapted where boreholes are only partially cased.

1. Before drilling the hole it is important to ascertain the depth at which the piezometer is to be installed. An indication of the ground conditions may also be helpful.

2. The borehole should be formed to a depth of approximately 500mm below the intended elevation of the piezometer tip. If a Bentonite plug is required at the base of the borehole, it will have to be drilled further to accommodate the plug.

3. Before commencement of installation, the depth of the hole should be re-checked and the procedure you intend to follow should be confirmed with the engineer and discussed with the driller.

4. Confirm that all materials are available (filter sand, Bentonite pellets or balls and backfilling grout). The piezometer to be installed should be transported to the borehole locations in a container of clean water (see section 5.1.13).

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5. Check the drill hole to ensure that the full depth is clear and free of obstructions and that any casing can be withdrawn.

6. CHECK BASE READING OF PIEZOMETER.

   Where necessary, record a reading from the piezometer to confirm that it has not been damaged since establishing the base readings (see Section 5.1)

7. Where necessary and possible, fill the borehole with clean water.

8. If a Bentonite plug is required at the base of the borehole, pull any temporary casing back so that it lowest level corresponds to the top of the intended plug. Slowly drop Bentonite pellets / balls down the borehole. Be sure not to let the pellets / balls plug or stick to the inside of the casing by checking the depth using a weighted tape. Ensure that the Bentonite level always remains below the bottom of the casing. (Feeding pellets / balls in to the borehole too quickly will result in ‘bridging’ of casing and make completion of the installation very difficult). The top of any base-plug must be below the intended piezometer installation elevation.

9. Once the plug has been formed (where required), the casing should be pulled to about 500mm (or in accordance with specification) above the new base of the borehole (the intended piezometer installation elevation) and filter sand should be slowly added to fill the borehole up to the depth at which the piezometer is to be installed.

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10. With the filter securely fitted to the piezometer, lower it slowly down onto the sand at the base of the borehole and record another check reading.

11. If necessary, coil up and feed the piezometer cable into the casing so that the drilling rig can be used to retract the casing. Ensure that there is enough slack cable to prevent the casing pulling the piezometer back up the borehole. (This will have to repeated whenever casing is to be raised or removed.) When a section of casing is removed it will have to be slid along the cable or the cable passed through it.

12. Pull the temporary casing back to the elevation of the top of the filter and add more clean filter sand on top of the piezometer. Continually check the level of the sand using the weighted tape.

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13. Pull the casing back another 500mm (or as project specification requires) and add a Bentonite seal of specified thickness. This should comprise pure Bentonite pellets / balls as described above for the base plug. Continue to pull the casing a little at a time whilst adding the Bentonite pellets. Once the borehole is sealed to the specified thickness, check piezometer readings again.

    (In a 100mm diameter borehole the 5kg of Geosense Mikolit® Bentonite pellets will produce a seal approximately 500mm long)

14. Fill the remaining void with Grout as shown in the grouting procedure (See Section 5.6).

15. The piezometer installation is now complete but the initial, in-situ piezometer readings have yet to be recorded. Since the piezometric balance may have been disturbed by the installation operations, a series of piezometer readings may have to be recorded so as to determine when the piezometric balance has re-established. Only then can a true set of in-situ pore pressure readings be recorded.

16. Terminate the installation as specified. It is important to terminate the cable above ground level in a waterproof enclosure or with a waterproof connector. Protect the installation from construction traffic and mark its location with a stake.

5.3.2 Open (Un-cased) Boreholes.

When forming a borehole for instrument installation, it may not be necessary to use a temporary steel sleeve or ‘casing’ to hold the hole open during drilling and installation operations. These holes may be described as ’open holes’. The following describes a series of steps that could be adopted to carry out a piezometer installation in an open or uncased borehole. It is similar to, but simpler than, the procedure for the cased borehole (5.3.1)

1. Before drilling the hole it is important to ascertain the depth at which the piezometer is to be installed. An indication of the ground conditions may also be helpful.

2. The borehole should be formed to a depth of approximately 500mm below the intended elevation of the piezometer tip. If a Bentonite plug is required at the base of the borehole, it will have to be drilled further to accommodate the plug.

3. Before commencement of installation the depth of the hole should be re-checked and the procedure you intend to follow should be confirmed with the engineer and discussed with the driller.

4. Confirm that all materials are available (filter sand, Bentonite pellets or balls and backfilling grout). The piezometer to be installed should be transported to the borehole locations in a container of clean water (see section 5.1.13).

5. Check the drill hole to ensure that the full depth is clear and free of obstructions.

6. CHECK BASE READING OF PIEZOMETER. Where necessary, record a reading from the piezometer to confirm that it has not been damaged since establishing the base readings (see Section 5.1)

7. Where necessary and possible, fill the borehole with clean water.

8. If a Bentonite plug is required at the base of the borehole, slowly drop Bentonite pellets / balls down the borehole. Be sure not to let the pellets / balls plug or stick to the inside of the borehole. Feeding pellets / balls in to the borehole too quickly will result in ‘bridging’ of the hole and make completion of the installation very difficult). The top of any base-plug must be below the intended piezometer installation elevation.

9. Once the plug has been formed (if required), filter sand should be slowly added to fill the borehole up to the depth at which the piezometer is to be installed. Use a weighted fibre tape to control the level of the filling materials.

10. With the filter securely fitted to the piezometer, lower it slowly down onto the sand at the base of the borehole and record another reading.

11. Add more clean filter sand on top of the piezometer to provide the required filter above the piezometer level. Continually check the level of the sand using the weighted tape.

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12. Add a Bentonite seal of specified thickness. This should comprise Bentonite pellets / balls as described above for the base plug. Once borehole is sealed to the specified thickness, check piezometer readings again.

13. Fill the remaining void with grout as detailed in the Section 5.6.

14. The piezometer installation is now complete. In-situ piezometer readings should now be recorded. Since the piezometric balance may have been disturbed by the installation operations, a series of piezometer readings may have to be recorded so as to determine when the pressure balance has re-established. Only then can a true set of in-situ pore pressure readings be recorded.

15. Terminate the installation as specified. It is important to terminate the cable above ground level in a waterproof enclosure or with a waterproof connector. Protect the installation from construction traffic and mark its location with a highly visible stake.

5.3.3 Push-in Installations

Some installations require a Piezometer to be pushed into undisturbed material at the bottom of a borehole or pushed into the ground from the surface. For this purpose, Geosense produces specially designed Push-in Piezometers. The installation involves the use of a pushing adaptor connected to steel placing rods, drilling rods or Cone Penetration Testing (CPT) rods. The rod(s) must be strong enough to withstand the load that will be required to push a piezometer body into the material at the base of the borehole or from ground level.

Only purpose built PUSH-IN piezometers can be used for this type of installation.

A special pushing adaptor is required to support and push the piezometer body into the base of a borehole. This adaptor is a purpose built component, normally manufactured by MGS Geosense, that can be supplied or modified to suit the size and thread of the drilling rods to which it will be connected. There are two types of pushing adaptor to match the two models of Push-in Vibrating Wire Piezometers supplied by Geosense. The design of the adapter is such that once the piezometer has been pushed to the required elevation, the rods and adaptor can be extracted, leaving the piezometer in place.

Where drilling rods are to be used to push the piezometer only into the base of the borehole, it is suggested that the cable from the piezometer passes out from the side of the pushing adaptor and up outside the rods. This will make it easier to withdraw the rods once the installation has been finalised. Obviously, the piezometer cable must not be attached to the drilling rods as the installation is inserted into the borehole and care must be taken to protect the cable.

For pushing deeper into a borehole base, the cable must remain inside the rods to protect it.

The borehole may be cased or un-cased. The final installation procedure will need to be created to include the following variations and based upon the previously described borehole installation procedures.

1. Prepare the piezometer and obtain the BASE READING as described in Section 4 and transport it to the drilling location.

2. Base grouting need not be carried out since the intention is that the piezometer will be pushed into un-disturbed material at the base of the borehole.

3. With the specially designed pushing shoe fitted to the lower end of the first rod, the piezometer must be pushed up inside the shoe until it is firmly in place against the back of the shoe.

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4. As the rods are lowered into the borehole, the cable must be restrained to prevent the piezometer dropping out of the shoe and to maintain control of the cable.

Never rotate the lower rods when adding further rods. This may cause the piezometer cable to become wrapped around the rods and will result in a failed installation due to either cable damage or pulling the piezometer back out of its intended location when the rods are extracted.

5. Always count the rods into the holes so as to be sure of the piezometer elevation at any time. (In soft ground, heavy rods could push the piezometer past its intended location without applying any driving force.)

6. When the piezometer is just above the base of the borehole connect a portable readout to the piezometer cable to monitor any changes in the pressure registered by the piezometer, particularly when it is being pushed into the base.

These pressures MUST NOT exceed the maximum pressure shown on the calibration sheet by more than 50%. If it does exceed the calibrated values by more than 50%, irreparable damage to the piezometers may occur. The calibration and Zero values would then be invalidated. The piezometer would not then provide any useful data.

7. If necessary, use hydraulic equipment (rig head or jacking ram) to apply gradual loading to the rods to push the piezometer to its intended elevation.

8. No filter zone is required. Bentonite pellets can be used to provide a plug behind the piezometer, but generally the borehole would be backfilled with Bentonite / Cement grout once the rods have been extracted. When water is present in the borehole, grouting must be carried out using a tremie pipe. Where the borehole is dry, liquid grout can be placed from the top.

Where a Cone Penetrometer Testing Rig (CPT rig) is to be used to push the piezometers, it will be necessary to use a special adaptor shoe and to run the piezometer cable up inside the CPT rods. Each rod must be threaded over the cable as pushing is carried out. A standard electronic CPT pushing head can be used to allow the cable to pass though under the pushing head. A pre-driven CPT hole with a fake head can also be utilised to prevent pressure build up on the piezometer.

This system can be a cost effective solution where piezometers are to be installed in soft ground but care must be taken not to damage the cable when the CPT rods are withdrawn.

5.3.4 Borehole Installation (Fully Grouted Method)

This is an alternative method of installing either single or multiple piezometers in a single borehole. Rather than creating a filter pocket or pushing the tip into the parent material, the piezometers are suspended in a borehole and the borehole is backfilled with only a suitable Cement & Bentonite grout.

1. Drill the borehole below the required depth of the piezometer. Flush the borehole with water or biodegradable drilling mud, to remove drilling fluids and cuttings.

2. Prepare the piezometer and obtain the BASE READING as described in Section 5.1 and transport it to the drilling location.

3. Tie the piezometer to its own signal cable, so that it can be lowered, filter-end uppermost, into the borehole. Weight may need to be added to the piezometer (in the form of a small bag of sand, or similar).

4. Measure along and mark the piezometer cable so it can be suspended in the borehole with its sensing diaphragm at the intended elevation.

5. If the piezometer is installed along with inclinometer casing, tape the piezometer (filter-end up) to the casing and also tape the cable to the casing along its length.

6. Lower the piezometer to its intended location, referring to the marks placed on the piezometer cable. Since no sand filter will be installed, the piezometer must be supported in the borehole by its cable, so that the grout can be placed. It must remain supported until the grout has reached an initial set.

7. Back-fill the borehole with grout. Use either of the grout mixtures detailed in Section 5.6 as a starting point for the grout mix. Add the cement to the water first, and then add the Bentonite. Adjust the amount of Bentonite to produce a grout that is 'just pump able' (heavy cream consistency). If the grout is too thin, the solids and the water will separate. If the grout is too thick, it will be difficult to pump.

8. Extreme care must be taken to ensure that the piezometer remains supported and un-disturbed whilst any drill casing is removed and the grout reaches an initial set.

9. Readings taken immediately after installation will be high, but will decrease as the grout cures. Once it has cured, the lag time caused by the grout itself is believed to be measured in minutes.

10. Terminate the installation as specified. It is important to terminate the cable above ground level in a waterproof enclosure or with a waterproof connector. Protect the installation from construction traffic and mark its location with a highly visible stake. Hydration of the grout may take time in low permeability soils and have an impact on the setting time.

5.4 Installation Procedures - Trenches and Pockets

This type of installation is carried out where the intended piezometer position is accessible. Commonly this would be during the construction of a structure where the piezometer would form part of a future monitoring regime. Typically this might include embankments, culverts, cut & cover tunnels, dams, etc.

In materials that have a low permeability, no sand pocket should be included in the installation since this would lead to a reduced response time and may provide a trap for air which would render the piezometer less responsive.

In granular materials, where permeability is medium or high, a sand filter pocket can be formed around the piezometer tip.

In some installations, particularly where saturation of the piezometer location is due to occur after a long period (dams for example), the piezometer can be orientated so that its filter end is raised above the cable entry end. This will help to minimise the risk of air being trapped around the diaphragm when saturation occurs.

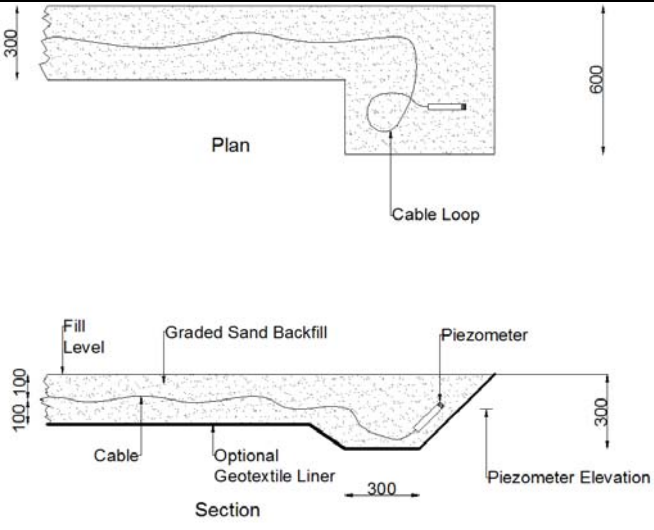
Alternatively, to maintain short term saturation (in highly permeable, tidal locations for example), piezometers can be installed with their filter downwards, in a small plastic container filled with saturated coarse sand. This will prevent water from draining away, thereby maintaining the tip in a saturated condition.

Once again, no two installations are the same but common practice in most materials involves excavating a small pit in the material in which the piezometer is to be installed. Once in position, the piezometer should be surrounded by the material in which it is being installed. This will ensure that its environment replicates, as closely as possible, the surrounding conditions.

Where piezometers have to be connected to extension cables, this would preferably be carried out prior to installation. In some cases, however, this may not be possible.

5.4.1 Permeable Materials

1. Once the cable route has been defined, excavate a trench (minimum 200mm deep) along the route from the piezometer installation location to the intended cable termination point. Where compaction of backfilled material is critical (dams for example), the trench should have sides raked at an angle of a minimum 45 degrees.



Piezometer in a pocket in a permeable material

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2. Create a small pocket (minimum 300mm x 300mm x 300mm) into which the piezometer can be installed. Check the elevation of the pocket to ensure that the piezometer will be installed at the correct level.

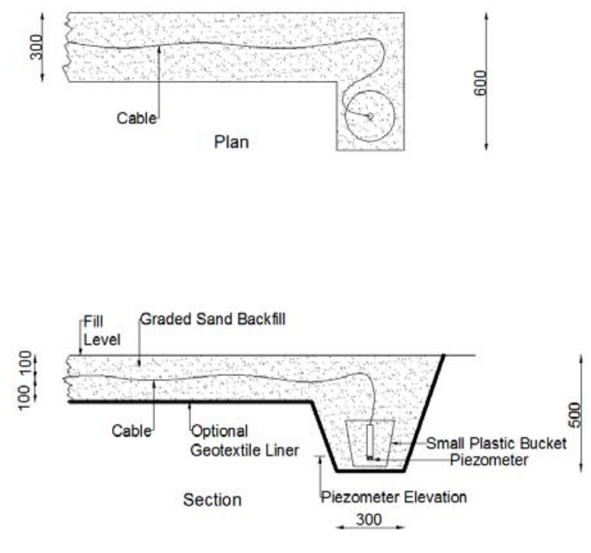
3. Where the excavation is in a granular material, place a layer of Geotextile material in the base and up the wall of the excavation, then a 100mm layer of graded sand in the base of the trench and pocket.

4. Having prepared the piezometer for installation and recorded its site Zero Reading (see Section 5.1), bring it to site for installation. Check the function of the piezometer using a portable readout.

5. Carefully remove the piezometer from the water filled container and place it in the sand pocket as shown.

6. Coil the cable in the pocket, to form a loop as shown. This helps to reduce the risk of cable damage due to excessive settlement or stretching.

7. Lay a section of the cable into the trench and backfill the pocket and trench with stone free sand as shown in the above sketch. It may help to pour some water over the sand to assist with compaction.

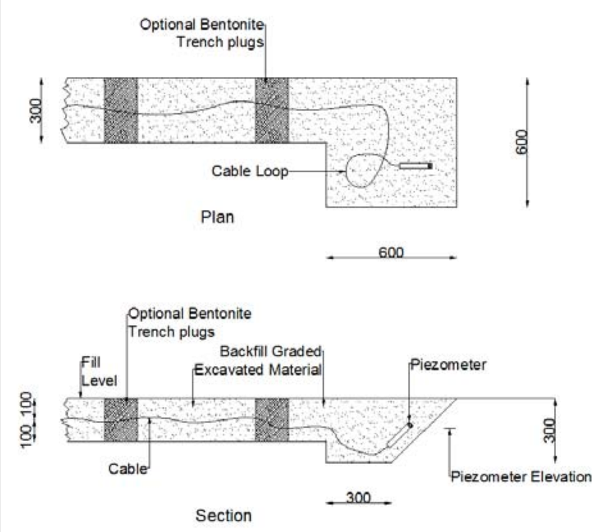


Piezometer in a pot in a permeable material

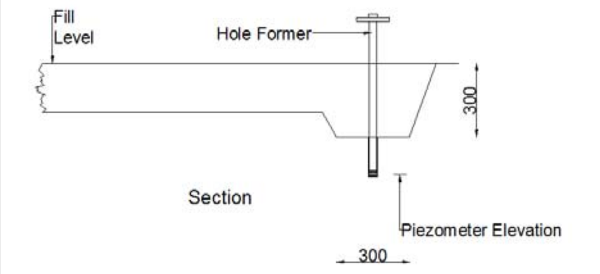
8. Complete the cable laying operation, snaking the cable in the trench only where specified, and backfill the trench with sand. (Laying the cable in a 'zig - zag' or 'snaking' pattern is sometimes specified with the intention of reducing the risk of cable breaks due to stretching. The preferred solution is to use a good quality cable <u>without</u> steel armouring, laid in a straight line).

9. Before resuming any further filling operations, check the function of the piezometer using a portable readout.

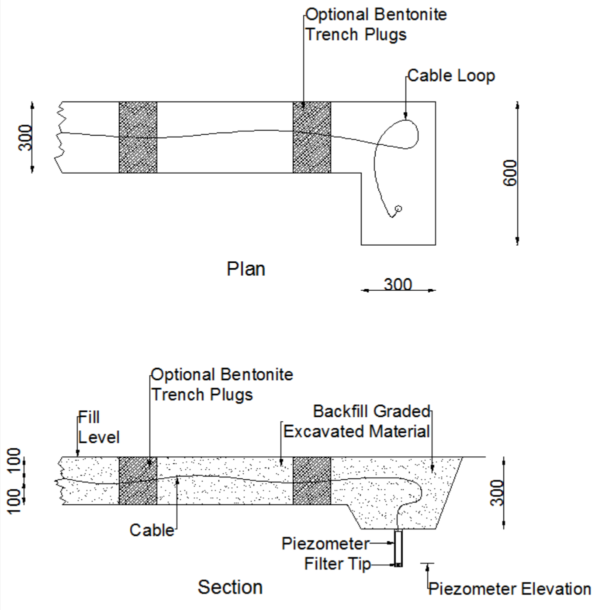
5.4.1 Impermeable Material



Piezometer in a pocket in an impervious material



Forming hole for Piezometer in impervious material



Piezometer pushed into an impervious material

1. Once the cable route has been defined, excavate a trench (minimum 200mm deep) along the route from the piezometer installation location to the intended cable termination point. Where compaction of backfilled material is critical, the trench should have sides raked at an angle of a minimum 45 degrees.

2. Place a minimum 100mm thick layer of graded backfill in the base of the trench. The backfill should be similar to the excavated material, graded to remove any stones or objects that may damage the cable. The backfill material must have a low permeability

3. Create a small pocket (minimum 300mm x 300mm x 300mm) into which the piezometer can be installed. Check the elevation of the pocket to ensure that the piezometer will be installed at the correct level. See sketches for level details.

4. The piezometer can be either placed in the pocket and surrounded with suitable backfill material or it can be pushed into a pre-formed socket in the base of the pocket.

5. To form a socket, make or obtain a ‘mandrel’. This should be the same diameter as the piezometer and the socket is generally formed so that the whole piezometer body can slide into it.

6. Place a 100mm layer of graded backfill in the base of the pocket.

7. Having prepared the piezometer for installation and recorded its site Zero Reading (see Section 5.1), bring it to site for installation in a water filled

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container. Check the function of the piezometer prior to its installation, using a portable readout.

8. Carefully remove the piezometer from the water filled container and place it in the pocket or into the socket, as shown in the sketches.

9. Coil the cable in the pocket, forming a loop as shown.

10. Lay a section of the cable into the trench and backfill the pocket and trench with graded material as shown in the sketch. Carefully compact the material around the piezometer by hand, and using **only** light hand held machines around the cable.

11. Complete the cable laying operation, snaking the cable in the trench only where specified, and backfill the trench with graded material, compacting it in layers to ensure an adequate seal.

12. Before resuming any further filling operations, check the function of the piezometer using the portable readout.

13. Bentonite can be used to provide additional sealing material. Either Bentonite powder can be mixed into all the backfill material used in the impervious zones or pellets / balls of partially saturated Bentonite can be used to form plugs at intervals along the cable route (see sketch).

5.5 Installation Procedures - Observation Wells or as Water Level Transducer

Vibrating Wire Piezometers can be installed in Observation Wells or Standpipe Piezometers to monitor water levels.

It must be remembered that the standard piezometer is a sealed unit and is, therefore, sensitive to any pressure on its diaphragm. When installed in a well that is open to atmosphere, the piezometer reading is affected by changes in atmospheric pressure in addition to any changes in water level.

When an accuracy better than ±150 mm head of water is required, atmospheric pressure must be monitored and the piezometer readings must be adjusted for changes in atmospheric pressure. Atmospheric pressure should be monitored by an on-site recording barometer or by a second low pressure range piezometer that is dedicated to monitoring atmospheric pressure.

Alternatively, special 'vented' Vibrating Wire Piezometers are available. In these instruments, the rear of the diaphragm is 'vented' to atmospheric pressure by a fine tube included in the special cable. This removes the need for barometric compensation as both side of the diaphragm are affected equally. They are often employed where only small operating pressures are expected.

Installation

1. Carry out all pre-installation checks and record the site zero reading as described in section 5.1 of this manual.
2. Measure and mark the cable to indicate the level at which it should be installed. It should be located either at the specified depth or just below the maximum expected drawdown level.
3. If turbulence is expected, fit a perforated centraliser to keep the piezometer stable inside the well.
4. Lower the piezometer into the well and secure the signal cable at the top so as to maintain the tip in position.
5. Terminate the installation as specified. It is important to terminate the cable above ground level in a waterproof enclosure or with a waterproof connector. Protect the installation from construction traffic and mark its location with a highly visible stake.

5.6 GROUTING

Backfilling of boreholes and other excavations for piezometer installation often calls for the preparation and installation of a grout.

Grout should be mixed in a purpose designed grout mixer so as to ensure a complete mix. However, and only as a last resort, grout can be mixed in a large container using a high volume pump for circulating, mixing and placing the liquid.

The grout is used as either a sealing compound, a void filling material, or as a combination of both. Commonly the components and proportions of the mixture are designed to reflect the characteristics of the material into which it is to be placed. Where a specific design is not required, generalisations can be made with regard to the mix proportions.

Since the materials also vary from batch to batch, it is important to use representative samples of the material that will be used on site, when preparing samples for lab testing and mix design.

Where the grout is to be used to backfill for a borehole, the commonly adopted mix proportions, by weight, would be :-

Grout Mix for Hard and Medium Soils		
Materials	Weight	Ratio by Weight
Portland cement	50 Kg (2 bags)	1
Bentonite	15 Kg	0.33
Water	125 Litres	2.5
Grout Mix for Soft Soils		
Materials	Weight	Ratio by Weight
Portland cement	50 Kg (2 bags)	1
Bentonite	20 Kg (as required)	0.4
Water	325 Litres	6.5

Other compounds can be added to the grout mixture to alter its characteristics:-

- Expanding agents are added to introduce small bubbles into a cement and water mix as it cures to prevent it from shrinking.
- Plasticisers can be added to a mixture to allow it to flow more freely through small bore pipe work.
- Fillers are added to provide weight and / or bulk to the mixture for use where grout may have a tendency to flow through the borehole walls.

6.0 DATA HANDLING

The function of an instrument is to provide useful and reliable data. Accurate recording and handling of the data is essential if it is to be of any value.

6.1 Monitoring the Piezometer Readings

Geosense Vibrating Wire Piezometers include both pressure and temperature sensors. Where a piezometer is installed in a zone where its temperature is likely to fluctuate significantly, records of both pressure and temperature data should be recorded. The can then be used to assess any temperature effects on the pressure readings.

6.1.1 Portable Readouts

Geosense offer a range of readout and data logging options. Specific operation manuals are supplied with each readout device.

Below is a brief, step-by-step procedure for use with the **RST VW2106** portable readout.

1. Connect signal cable from the sensor to the readout following the wiring colour code. Conductor colours may vary depending upon the extension cable used. Commonly these are:

RED	=	VW +
BLACK	=	VW -
GREEN	=	Temp
WHITE	=	Temp

2. Switch on the unit and, where necessary, select range B

3. The readout displays the Vibrating Wire reading (in $Hz^2/1000$ - Linear Digits) and a temperature reading in degrees C.

Whilst it is not critical that the polarity be observed for most Vibrating Wire instruments, a better signal may be obtained if the correct polarity is adopted. Since the temperature sensor is a Thermistor, its connection polarity is not important.

6.1.2 Data Loggers

A number of data loggers are available to automatically excite, interrogate and record the reading from Vibrating Wire instruments. These include devices manufactured by Geosense / RST in both single and multi-channel configurations, as well as equipment manufactured by independent suppliers.

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Geosense configure and supply equipment manufactured by both Campbell Scientific Ltd and DataTaker Ltd. These are the most commonly adopted third party manufacturers of data loggers that can be used with Vibrating Wire Instruments. Specific configuration and programming advice can be obtained from Geosense and or the manufacturers documentation.

6.2 Data Reduction

Overview

Readings from a Vibrating Wire Piezometer are typically in a form that is a function of frequency rather than in units of pressure. Commonly the units would be either **Frequency** - Hertz, **Linear** - $Hz^2/1000$ or $Hz^2/1000000$ or **Period** - Time - (Seconds $x10^{-2}$ or $x10^{-7}$).

To convert the readings to units of pressure, calibration factors must be applied to the recorded values. For most Vibrating Wire sensors, these factors are unique and are detailed on the sensor calibration sheet. A unique calibration sheet is supplied with all Geosense Vibrating Wire Piezometers.

If the readout display is in Period units (e.g. 0.03612 or 3612 - depending upon the readout used) the first step to producing an engineering value is to convert the reading to Linear Digits ($Hz^2/1000$) . Two examples of this calculation can be seen below. The first (1) where the readout includes a decimal point and displays the Period in ***Seconds***$^{-2}$ and the second (2) where the readout displays the Period in ***Seconds***$^{-7}$

(1) Readout Display = 0.03612

Linear Digits ($Hz^2/1000$) = $(1 / 0.03612^{-2})^2 / 1000$

= 7664.8

(2) Readout Display = 3612

Linear Digits ($Hz^2/1000$) = $(1 / 3612^{-7})^2 / 1000$

= 7664.8

If the readout displays 'Frequency' values, (e.g. 2768.5 Hz) only a simple calculation is required to convert the readings to Linear Digits.

Linear Digits ($Hz^2/1000$) = $(2768.5)^2 / 1000$

= 7664.6

Certain data loggers store their Vibrating Wire data in Linear Digits but further divided by 1000. In this case the data would have to be multiplied by a further 1000 to maintain the standard Linear Digits ($Hz^2/1000$) format for standard calculations.

There are many ways to achieve the conversion from recorded data to useful engineering values. The following are included as a guide only and as a basis for alternative approaches.

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Linear Calculation

This is the most simple calculation to convert ‘raw’ data to engineering units. It can be easily carried out using a simple calculator. It assumes that the reading is in Linear Digits ($Hz^2/1000$). Where this is not the case, the reading should be converted to these units prior to application of the calibration factors. For most applications this equation is perfectly adequate and is carried out as follows:

Pressure (psi) = Linear Factor for psi (k) x (Current Reading - Base Reading)

Polynomial Calculation

This calculation is slightly more precise, as it accommodates some of the slight deviation of the data from a straight line. However, in its standard form it does not easily accommodate site recorded base reading or environmental changes that may affect the zero (such as altitude).

Pressure (psi) = *[Factor A for psi x (Reading)^2] + [Factor B for psi x Reading] + Factor C for psi*

Where the Pressure is required in an alternative format, mH_2O for example, a simple conversion using standard conversion factors can be applied to each factor or at the end of the equation. (1 psi = 0.7031 mH_2O for example).

An instrument calibration sheet similar to the example in the appendix of this manual includes the following information:

Model	This refers to the Geosense or RST model number.
Serial Number	This is a unique sensor identification number that can be found on the cable just behind the piezometer body and, for long cables, at the end of the cable.
Works ID	Unique works batch and range code
Cal Date	Date the calibration was performed
Baro	Barometric Pressure at the time of calibration
Temp ^oC	Temperature at which the piezometer was calibrated
DPI No.	Serial number of the Digital Pressure Indicator used in conjunction with the pressure generator
Readout No.	Serial Number of the readout used to display the transducer output
R/O Cal Date	The date on which the Readout was calibrated to a traceable standard
Applied Pressure	Pressure applied to the transducer as part of the calibration cycle in both psi and kPa
Readings [digit]	Readings from the transducer as pressure is applied and as pressure is reduced, in steps. The average is calculated.
Calculated Pressure	Calculation of the applied pressure using the calculated Linear

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	and Polynomial for comparison with the actual Applied Pressure.
Non Lin. % fso	Non Linearity expressed as a percentage of the transducers Full Scale.
Calibration Factors	'Linear' and 'Polynomial' factors are provided for a selection of engineering units (other units can be calculated directly from the kPa values). Examples of calculated values are detailed below.

The following are examples of data reduction calculations and are based upon the piezometer to which the attached example calibration sheet refers.

A. An example of the calculation from Period units (Seconds $^{-7}$) to Metres of Water (mH_2O) using a Linear equation is given below:-

Site Zero Reading = 3235
Zero Converted to Linear Digits = 9555.5
Calibration Factor for mH_2O (K) = - 0.18159

Current Reading = 3289
Current Converted to Linear Digits = 9244.3

Equation

Water Pressure mH_2O = K x (Current Reading - Base Reading)
Water Pressure mH_2O = -0.018159 x (9244.3 - 9555.5)
Water Pressure mH_2O = 5.651m

B. An example of the calculation from Linear Digits (Hz^2/1000) to kPa using a Polynomial equation is given below:-

Calibration Factors for kPa A = - 6.3014 $^{-7}$
B = - 0.1685013
C = 1664.594

Current Reading in Linear Digits = 9244.3

Equation

Pressure in kPa = [A x (Reading)^2] + [B x Reading] + C
= [- 6.3014 $^{-7}$ x (9244.3)^2] + [- 0.1685013 x 9244.3] + 1664.594
= - 53.85 - 1557.67 + 1664.59
= 53.07 kPa

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Barometric Pressure Considerations

In some locations, barometric pressure varies only a little, except when there are storms. In other locations, normal weather may bring barometric pressure changes as large as 34 mb (0.5 psi) during a day, and 68 mb (1 psi) during a year.

If a piezometer is sealed into a borehole to measure pore-water pressure, the only pressure acting on the piezometer's diaphragm is the water pressure at that depth, so a barometric correction need not be applied. Even if it is later found that there is a relationship between barometric pressure and pore-water pressure, it will probably not be necessary to apply any correction as any influence will be negligible.

If the transducer is measuring the water level in a standpipe or well that is open to atmosphere, the pressure measured by the piezometer is the combined pressure of water and the air above the surface of the water. If the barometric pressure drops, the piezometer will return a decreased pressure, even if the water level remains unchanged. To eliminate the measurement uncertainty introduced by changes in barometric pressure, a correction can be applied.

Either a special barometric transducer or an additional low pressure piezometer can be used to measure atmospheric pressure. The following is an example of how to carry out the correction using data from a special barometric transducer or other weather station information:-

1. Obtain barometric pressure readings on site at the time of reading the piezometer. Ideally the barometer should provide the actual pressure of the atmosphere at the location of the monitoring site. Off-site reports from weather stations can also be adequate for this purpose since it is only the relative change in pressure that will be used to calculate the effect. The same source of pressure that was noted when the piezometer zero values recorded must be used for all subsequent readings.

2. Subtract the barometer reading obtained when the site zero value was recorded, from current barometer reading in millibars. This is the barometric pressure correction value.

3. Convert the barometric correction value to the engineering units being used for the piezometer data, by multiplying it by the applicable factor (for example:- 0.1 for kPa, 0.014504 for psi or 0.0101972 for mH_2O)

4. Add the barometric correction, in engineering units, to the pressure reading, remembering that the compensation could be positive or negative.

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Example

Zero Reading in Linear Digits		9555.5
Atmospheric Pressure when Zero recorded		1022mb
Current Reading in Linear Digits		9244.3
Current Atmospheric Pressure		1007mb
Calculated water pressure in mH_2O (see prev. section)		5.651m
Change in Atmos Pressure (Current - Zero)	=	1007 - 1022 mb
	=	- 15 mb
Convert mb change to mH_2O (15 x 0.0101972)	=	$-0.153mH_2O$
Compensate for pressure change (5.651+(- 0.153))	=	**$5.498mH_2O$**

Where a low pressure piezometer is used to measure the barometric pressure, the atmospheric pressure data can be recorded in the same units as the other piezometers, making compensation a simple addition of the difference (positive or negative).

Temperature Considerations

Where the piezometer is sealed in a borehole or buried in fill, there is usually little variation in temperature, so temperature effects will be small and corrections will not be necessary.

However, if a low range piezometer is suspended in a shallow standpipe or well, it may be affected by day to day changes and seasonal changes in temperature. In this instance, temperature corrections could become more important.

Thermal influences on Piezometer readings are complex. Therefore, in order to correct for temperature it is first necessary to establish the effects of temperature changes on a particular piezometer and the medium in which it is installed. (It must be remembered that the density of water also changes with temperature).

To establish the true affects of temperature changes, it is necessary to accurately verify the head acting on a particular piezometer using an alternative means. It is necessary to record both the water pressure from the piezometer, the piezometer temperature and the true water depth over the piezometer diaphragm. Over a full annual cycle, both the seasonal and daily thermal affects can be computed from these data.

Corrections would be carried out using a similar principle as for Barometric Pressure.

7.0 MAINTENANCE

The Vibrating Wire piezometer is a maintenance free device for most applications. This is because it is intended for sub-surface installation and would normally be irretrievably sealed into boreholes or fill materials.

However, when the piezometer is installed in a location where a flow of water moves past it and it can be recovered, a check should be made to determine the condition of the filter. If any crystalline chemical deposits or algae are present on or in the filter, it could affect the performance of the filter / piezometer.

It may be necessary to determine the nature of any build up, so that a suitable chemical compound can be sourced to dissolve the build up, without damaging the stainless steel of the body, filter and diaphragm. The body and sintered filter are fabricated from Grade 316 stainless steel, the white coloured filter (HAE) is a ceramic material and the pressure sensing diaphragm is Grade 17/4 stainless steel. There is also a Nitrile rubber 'O' ring sealing the diaphragm and the stainless steel body.

It would only be necessary to resort to dissolving any build-up if it either blocked the filter or there was <u>any sign</u> of build up on the surface of the diaphragm.

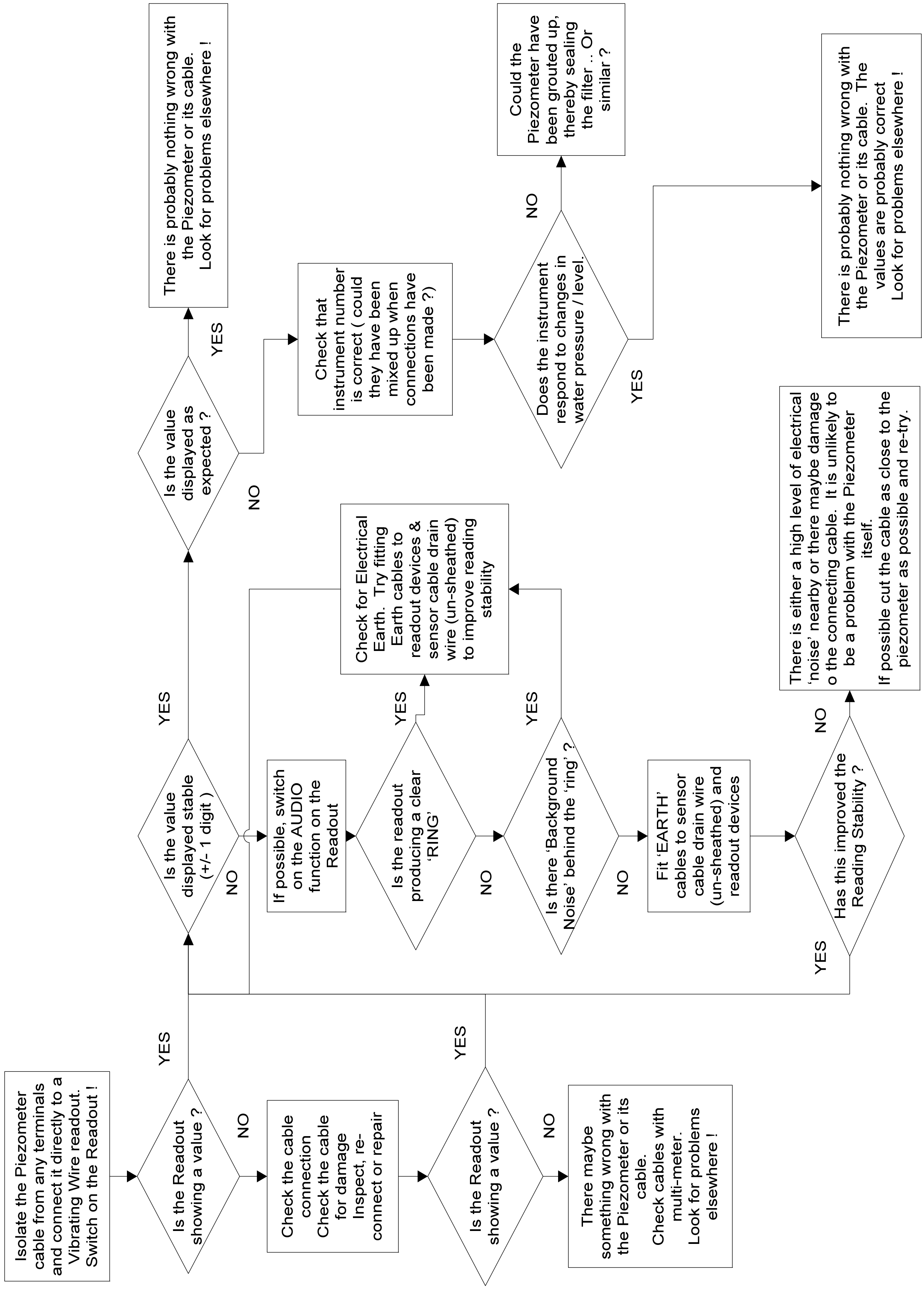
Maintenance of wiring connections between the piezometer and any terminal panels / or loggers should involve occasional tightening of any screw terminals to prevent loose connections or cleaning to prevent the build up of corrosion.

8.0 TROUBLESHOOTING

It is generally accepted that when a Vibrating Wire instrument is producing a stable reading on a suitable readout, the value will be correct. Only on <u>very</u> rare occasions will this be untrue.

In almost all cases, a fluctuating reading is a sign of a faulty signal from the sensor. The fault could be in either the sensor, the connecting cable, any switch boxes or the readout. The best way to fault find an instrument is to isolate it from all other instruments and connections. Where possible begin fault finding from the sensor itself.

A fault finding flow diagram is included on the next page, to help with troubleshooting.


Isolate the Piezometer cable from any terminals and connect it directly to a Vibrating Wire readout. Switch on the Readout !
Is the Readout showing a value ?
YES
NO
Check the cable connection
Check the cable for damage
Inspect, re-connect or repair
Is the Readout showing a value ?
YES
NO
There maybe something wrong with the Piezometer or its cable.
Check cables with multi-meter.
Look for problems elsewhere !
Is the value displayed stable (+/- 1 digit)
YES
NO
If possible, switch on the AUDIO function on the Readout
Is the readout producing a clear 'RING'
YES
NO
Check for Electrical Earth. Try fitting Earth cables to readout devices & sensor cable drain wire (un-sheathed) to improve reading stability
Is there 'Background Noise' behind the 'ring' ?
YES
NO
Fit 'EARTH' cables to sensor cable drain wire (un-sheathed) and readout devices
Has this improved the Reading Stability ?
YES
NO
There is either a high level of electrical 'noise' nearby or there maybe damage o the connecting cable. It is unlikely to be a problem with the Piezometer itself.
If possible cut the cable as close to the piezometer as possible and re-try.
Is the value displayed as expected ?
YES
NO
There is probably nothing wrong with the Piezometer or its cable.
Look for problems elsewhere !
Check that instrument number is correct (could they have been mixed up when connections have been made ?)
Does the instrument respond to changes in water pressure / level.
YES
NO
Could the Piezometer have been grouted up, thereby sealing the filter .. Or similar ?
There is probably nothing wrong with the Piezometer or its cable. The values are probably correct
Look for problems elsewhere !

9.0 SPECIFICATION

	VWP-3000 series						
Type	**VWP-3000**	**VWP-3001**	**VWP-3100**	**VWP-3101**	**VWP-3200**	**VWP-3201**	**VWP-3300**
Filter Type	**LAE**	**HAE**	**LAE**	**HAE**	**LAE**	**LAE**	**NA**
Length mm	**140**		**151**		**218**	**151**	**218**
Diameter mm	**20**		**25**		**25**	**25**	**35**

Resolution	±0.025% Full Scale
Accuracy	± 0.1% Full Scale
Thermal Effect	Less than 0.02% Full Scale per ^{o}C **
Operating Range	-20 to + 80 ^{o}C
Over Range Capacity	Minimum 2 x working range
Temperature Sensor	Thermistor (3kΩ @ 25^{o}C)
Surge Protection	Semitron Bi Polar 230V
Excitation	Pluck or Swept Frequency
Filter Options	Ceramic (3 bar air entry) Sintered Stainless Steel 316 - 50 Micron
Standard Pressure Ranges	

PRODUCTS	Kips	PSI	M (Water)	Bar	KPa
	0.03	**25**	17.5	1.72	172
Vibrating	0.05	**50**	35	3.45	345
Wire	0.08	**75**	52.5	5.17	517
Piezometers	0.10	**100**	70	6.89	689
	0.15	**150**	105	10.34	1034
	0.30	**300**	210	20.68	2068
	0.50	**500**	350	34.47	3447
	0.75	**750**	525	51.71	5171
	1.00	**1000**	700	68.95	6895

** When the temperature has stabilised to remove any thermal gradients across the sensor.

The above technical specification is accurate at the time of the last document revision and is intended as guide only.

The information above is liable to change without notice and may not, therefore, be 100% accurate for the supplied sensors.

10.0 SPARE PARTS

As a Vibrating Wire Piezometer is a sealed unit, it is neither serviceable nor does it contain any replaceable parts.

Replacement filter units are available as follows:-

Part number	**Description**
VWT-300101	LAE (Low Air Entry) filter assembly
VWT-300102	HAE (High Air Entry) filter assembly.

Civil engineering sites are hazardous environments and instrument cables can be easily damaged if they are not adequately protected. Geosense can therefore provide the following parts that may be required to effect repairs to instrument cables:

- PU coated 4 Core cable with foil shield and copper drain.
- PVC coated, armoured, 4 Core cable suitable for direct burial.
- Epoxy jointing kit for forming a waterproof cable joint.

Please contact Geosense for price and availability of the above components.

11.0 RETURN OF GOODS

11.1 Returns procedure

If goods are to be returned for either service/repair or warranty, the customer should contact MGS Geosense for a **Returns Authorisation Number,** request a **Returned Equipment Report Form QF034** and, where applicable, a **Returned Goods Health and Safety Clearance Form QF038** prior to shipment. Numbers must be clearly marked on the outside of the shipment.

Complete the **Returned Equipment Report Form QF034**, including as much detail as possible, and enclose it with the returned goods.

All returned goods are also to be accompanied by a completed **Returned Goods Health and Safety Clearance Form QF038** attached to the outside of the package (to be accessible without opening the package) and a copy of both forms should be faxed or emailed in advance to the factory.

11.1.1 Chargeable Service or Repairs

Decontamination
In some environments in which the piezometer are used, it is inevitable that they will be contaminated when returned to MGS Geosense. MGS Geosense is duty bound to de-contaminate any such piezometers that are returned. There is a standard charge for de-contamination, (please contact MGS Geosense for details).

Inspection & estimate
It is the policy of MGS Geosense that an estimate is provided to the customer prior to any repair being carried out. A set charge for inspecting the equipment and providing an estimate is also chargeable.

11.1.2 Warranty Claim

(See Limited Warranty Conditions)
This covers defects which arise as a result of a failure in design or manufacturing. It is a condition of the warranty that the Vibrating Wire Piezometer must be installed and used in accordance with the manufacturer’s instructions and has not been subject to misuse.

In order to make a warranty claim, contact MGS Geosense and request a **Returned Equipment Report Form QF034.** Tick the warranty claim box and return the form with the goods as above. You will then be contacted and informed whether your warranty claim is valid.

11.2 Packaging and Carriage

All used goods shipped to the factory **must** be sealed inside a clean plastic bag and packed in a suitable carton. If the original packaging is not available, MGS Geosense should be contacted for advice. MGS Geosense will not be responsible for damage resulting from inadequate returns packaging or contamination under any circumstances.

11.3 Transport & Storage

All goods should be adequately packaged to prevent damage in transit or intermediate storage.

12.0 LIMITED WARRANTY

The manufacturer, (**MGS Geosense)**, warrants the **Vibrating Wire Piezometer** manufactured by it, under normal use and service, to be free from defects in material and workmanship under the following terms and conditions:-

Sufficient site data has been provided to **MGS Geosense** by the purchaser as regards the nature of the installation to allow **MGS Geosense** to select the correct type and range of **Vibrating Wire Piezometer** and other component parts.

The **Vibrating Wire Piezometer** equipment shall be installed in accordance with the manufacturer's recommendations.

The equipment is warranted for 1 year from the date of shipment from the manufacturer to the purchaser.

The warranty is limited to replacement of part or parts which, are determined to be defective upon inspection at the factory. Shipment of defective part or parts to the factory shall be at the expense of the Purchaser. Return shipment of repaired/replaced part or parts covered by this warranty shall be at the expense of the Manufacturer.

Unauthorised alteration and/or repair by anyone which, causes failure of the unit or associated components will void this **LIMITED WARRANTY** in its entirety.

The Purchaser warrants through the purchase of the Vibrating Wire Piezometer equipment that he is familiar with the equipment and its proper use. In no event shall the manufacturer be liable for any injury, loss or damage, direct or consequential, special, incidental, indirect or punitive, arising out of the use of or inability to use the equipment sold to the Purchaser by the Manufacturer.

The Purchaser assumes all risks and liability whatsoever in connection with the Piezometer equipment from the time of delivery to Purchaser.

12.0 APPENDIX

VW piezometer specification

Mikolit™ specification

Bentonite specification

Sample VW piezometer calibration sheet

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