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EXTENSOMETER

Category: Instrumentasi Geoteknik - Extensometer

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TAPE EXTENSOMETER

GEOKON®

MODEL 1610

Model 1610 Tape Extensometer.

APPLICATIONS

The Model 1610 Tape Extensometer is designed for the measurement of small changes of distance between two points located in or on:

- Tunnels and mine openings
- Buildings and structures

OPERATING PRINCIPLE

The Model 1610 is based on a design by Peter Ealey. It measures the change in distance between pairs of eyebolts mounted on the walls of tunnels, in structures, or on unstable slopes, etc.

The Model 1610 uses a stainless steel measuring tape in which holes have been punched at precise intervals (every 50.00 mm or 2.000 inches). The tape is held inside a frame, which also houses a digital micrometer and electronic tensioning device. In use, the hook on the end of the tape is clipped onto the first eyebolt and then the tape is allowed to unreel until the hook on the end of the tape extensometer frame can be clipped to the second eyebolt. The slack is taken out of the tape and a pin on the frame is then located in one of the holes in the tape. The tape-tensioning handle is now turned, shortening the length of the frame, and increasing the tension on the tape. When the correct tension has been achieved, as indicated by a system of red and green lights, the digital micrometer is read.

This procedure is repeated from time to time so that any difference in the readings is a measure of a change in distance between the two eyebolts.

ADVANTAGES AND LIMITATIONS

The Model 1610 Tape Extensometer uses a machine-punched stainless steel tape set in a frame housing an electronic digital micrometer. The length of the frames and the tapes are carefully controlled during manufacturing, making them fully interchangeable. Damaged or broken tapes can be replaced without significant loss in data continuity.

The tapes are very light, so that errors due to sag are minimal, and they are made from stainless steel for corrosion resistance.

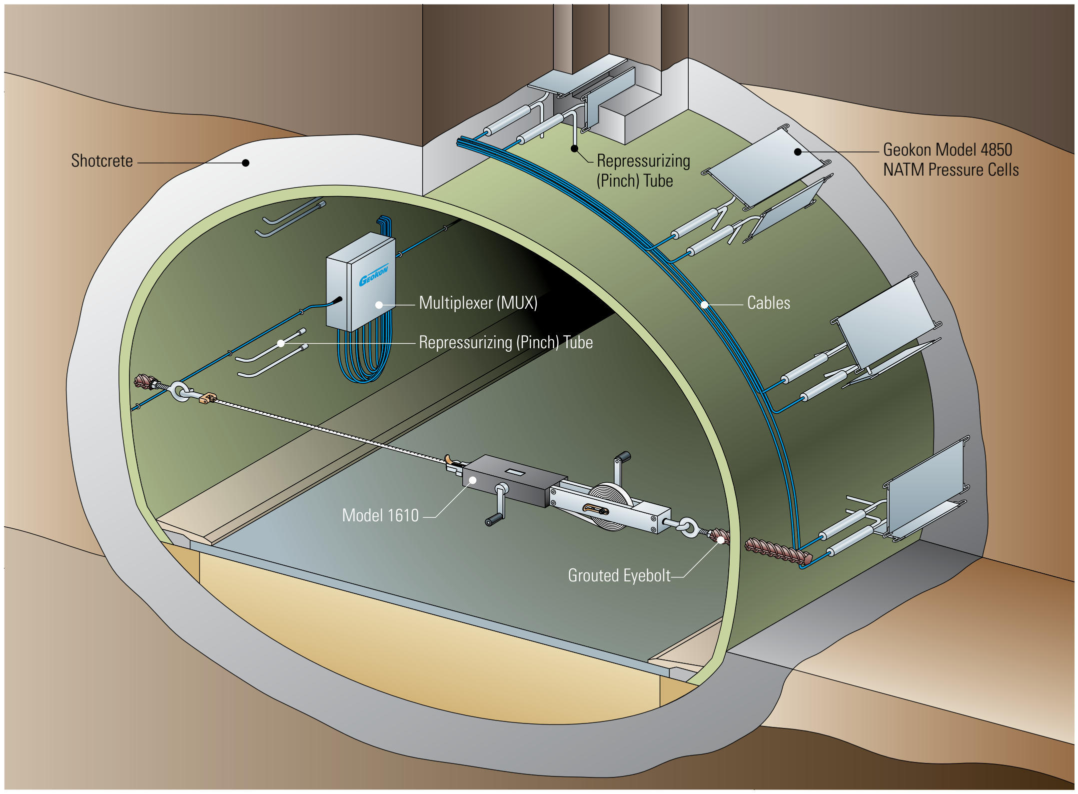
The Model 1610 has a user-friendly winding handle for tensioning the tape that greatly reduces the time and effort required to take readings. The correct tape tension is indicated by means of an electronic tension indicator, which eliminates the need to align index marks by eye. Accuracy to 0.1 mm is easily achievable.

Under most underground conditions, the digital readout is easier to read than a dial indicator. However, in bright sunlight the display may be difficult to read.

A yearly maintenance service is available and recommended to keep the extensometer in good condition.

Model 1610 shown with carrying case.

Model 1610-10 Hook Manipulator.



The Model 1610 as used to monitor the efficacy of concrete linings in tunnels supported by shotcrete (NATM).

SYSTEM COMPONENTS

The Model 1610 Tape Extensometer consists of a frame which houses an electronic digital micrometer, a tape tensioning handle and an electronic tape tensioning system with red and green indicator lights. A button located on the side of the frame enables the digital depth micrometer to be turned on and off and allows the zero reading to be reset.

The stainless steel tape is clipped into the frame and may be removed easily for replacement or cleaning. A sliding tape clip prevents the locating pin from slipping off the tape while it is being tensioned.

The tape extensometer is supplied in a sturdy carrying case complete with operating manual.

Accessories include groutable style eyebolts for use in concrete tunnel linings, or for installation in boreholes drilled in rock. Expansion type anchors may also be used in boreholes. Weldable or boltable style eyebolt anchors are available for attachment to steel supports or structures.

Accessories are also available to enable the tape extensometer to be used in large diameter tunnels without the need for ladders or scaffolding (see Model 1610-10 Hook Manipulator, left inset).

The use of a zero reading test frame is recommended to detect any change in the overall length of the tape extensometer assembly with time.

TECHNICAL SPECIFICATIONS

Tape Lengths	20, 30, 50 m and 66, 100, 165 ft
Tape Tension	10 kg
Accuracy	±0.1 mm
Indicator Battery	9 Volts (pp3)
Digital Micrometer Battery	3 Volts (CR 2032)
Weight	2 kg
Overall Length	520 mm
Operating Temperature Range	0°C to +50°C
Case Dimensions	500 × 350 × 125 mm

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www.geokon.com
e: info@geokon.com
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MAGNETIC EXTENSOMETER

GEOKON®

MODEL 1900

Model 1900-11 Reed-Switch Probe and Index Marker.

APPLICATIONS

The Model 1900 Magnetic Extensometer is designed for the measurement of settlement or heave of soft ground in or around:

- Excavations
- Foundations
- Dams
- Embankments
- Sheet piles and slurry walls
- Tunnels

OPERATING PRINCIPLE

The Model 1900 Magnetic Extensometer is designed to measure settlement or heave of soft ground under the influence of loading or unloading due to the construction of embankments, fills, buildings, and structures.

A reed-switch probe is used in conjunction with magnetic anchors positioned at various depths in a borehole drilled in soft ground or positioned inside fill material as it is placed on the original ground surface. A 1" schedule 80 PVC access tube or a 70 mm OD Inclinometer casing passes through the various anchors and allows the reed-switch probe to be lowered inside the tube on the end of a nylon-coated steel graduated tape.

The steel tape contains two conductors which connect the reed switch inside the probe to a light and a buzzer located inside the tape reel. When the probe is positioned opposite an anchor, the magnet in the anchor causes the reed switch to close and the buzzer to sound. The tape (which is graduated in $\frac{1}{10}$ in or mm) is then read opposite an index mark located at the top of the access tube or inclinometer casing.

ADVANTAGES AND LIMITATIONS

The design of the Model 1900 Magnetic Extensometer provides a means for determining the total displacement and the displacement for each inter-anchor zone.

In most cases, the bottom of the access tube, or inclinometer casing, is deep enough to be located in solid ground. A datum magnet anchored to the bottom of the access tube or inclinometer casing provides a stable benchmark to which all other measurements are referred.

The absolute settlement of each anchor point relative to the benchmark can be calculated.

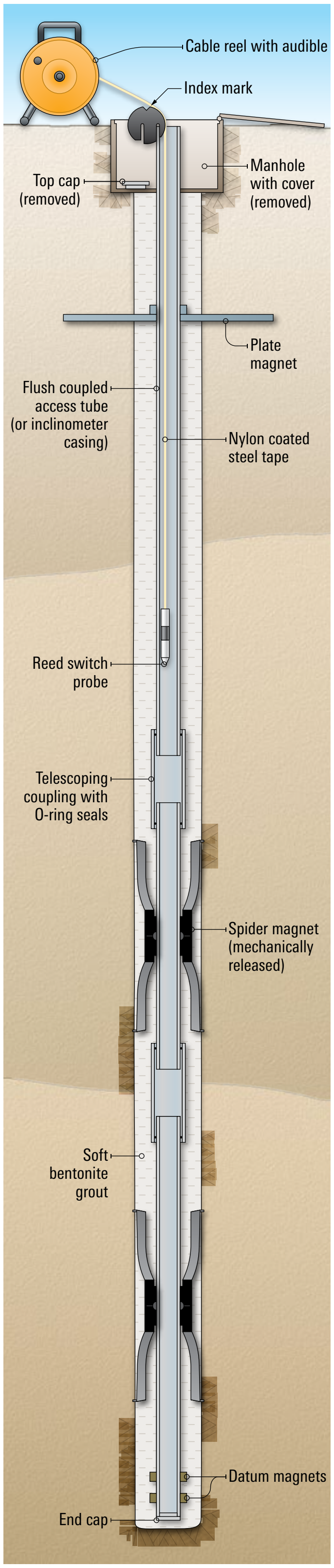
If the bottom of the access tube or inclinometer casing cannot be located in the solid ground, then it will be necessary to reference the position of each anchor to the top of the access tube or inclinometer casing. Then to transfer this elevation to an external benchmark by normal level surveying techniques.

Model 1900-5A (left) and Model 1900-5B (right) Datum Ring Magnets.

Model 1900-7A Anchor, shown before and after release on 1" access tube.

Model 1900-7B Anchor, shown before and after release on 6600 Inclinometer casing.

SYSTEM COMPONENTS



A typical Model 1900 installation.

Three types of anchors are available. In fills, square or circular plate magnets are used. "Spider" anchors, with six mechanically activated leaf springs, are used in boreholes. The leaf springs are closed until the anchor is at its correct location inside the borehole when a release mechanism is actuated, causing the springs to open and grip the sides of the borehole.

The third type of anchor is similar to the spider type, except that it has only three springs. This type is installed inside the borehole using setting rods to push it down the access tube until it is at the correct depth. The leaf springs exert a continuous outward force and scrape along the borehole walls as they are pushed into the hole.

Datum magnets are fixed to the bottom of the access tube or inclinometer casing and serve as a reference or datum that is assumed to be in a fixed position, i.e., below the settlement zone. The positions of all the magnetic anchors above are referenced to the datum magnets to calculate the settlement amount in the various inter-anchor zones. If the datum magnets cannot be located in stable ground, it will be necessary to periodically survey the top of the access tube or inclinometer casing.

The access tube comprises lengths of 1" Sch. 80 flush-coupled PVC pipe. Where large settlements are anticipated, telescoping sections should be incorporated into the access tube column (see illustration at left).

SPECIFICATIONS

Tape Lengths	30, 50, 100, 150, 200 m; 100, 125, 200, 300 ft
Resolution	1mm
Repeatability	±3 mm
Temperature Range	–30 °C to +80 °C
Probe Material	Stainless Steel
Probe Dimensions	178 × 19 mm (L × Ø)
Access Tube	PVC 1" sch. 80 (33 mm O.D.)
Inclinometer Casing[1]	70 mm O.D.
Telescoping Section	1 m (460 mm fully compressed)
Plate Magnet Material	PVC
Plate Magnet Dimensions	300 mm × 300 mm × 60 mm (9.5 mm Plate)
Spider Magnet Material	(body) ABS Plastic (legs) Hardened 17-7 SS
1900-7A Spider Magnet Dimensions	(closed) 430 × 70 × 34 mm (L × O.D. × I.D.) (released) 410 × 190 × 34 mm (L × O.D. × I.D.)
1900-7B Spider Magnet Dimensions	(closed) 430 × 120 × 73 mm (L × O.D. × I.D) (released) 410 × 228 × 73 mm (L × O.D. × I.D.)
Leaf Spring (Leg) Stiffness	> 20N
Datum Magnet Material	ABS Plastic
1900-5A Datum Magnet Dimensions	51 × 70 × 34 mm (L × O.D. × I.D.)
1900-5B Datum Magnet Dimensions	51 × 110 × 73 mm (L × O.D. × I.D.)
Borehole Size	102 to 216 mm

[1]Refer to Model 6400, 6500, and 6600 data sheets for inclinometer casing specifications.

ORDERING INFORMATION

1900-1-10: Flush coupled access tube, 1" SCH 80 PVC, 10' / 3 m length standard.
1900-1-5: Flush coupled access tube, 1" SCH 80 PVC, 5' / 1.5 m length standard.
1900-2: Telescoping coupling, Total length: 1 m (allows for 0.54 m of compression).
1900-4: Access tube bottom end cap.
1900-5A: Datum Ring Magnet for 1" PVC pipe.
1900-5B: Datum Ring Magnet for 2.75" Glue and Snap casing.
1900-5C: Datum Ring Magnet for 3.34" Glue and Snap casing.
1900-6A: Plate Magnet for 1" PVC pipe.
1900-6B: Plate Magnet for 2.75" Glue and Snap casing.
1900-6C: Plate Magnet for 3.34" Glue and Snap casing.
1900-7A: Spider Magnet (double-ended) for 1" PVC pipe.
1900-7B: Spider Magnet (double-ended) for use over 2.75" Inclinometer casing.
1900-7C: Spider Magnet (double-ended) for use over 3.34" Inclinometer casing.
07-062G-E: Galvanized Aircraft Cable, 1/16"
07-062G-M: Galvanized Aircraft Cable, 1/16"
1900-10: Access tube top cap.
1900-11-30M: Reed switch probe, with 30 meter measurement tape.
1900-11-50M: Reed switch probe, with 50 meter measurement tape.
1900-11-100M: Reed switch probe, with 100 meter measurement tape.
1900-11-150M: Reed switch probe, with 150 meter measurement tape.
1900-11-200M: Reed switch probe, with 200 meter measurement tape.
1900-11-100E: Reed switch probe, with 100' measurement tape.
1900-11-125E: Reed switch probe, with 125' measurement tape.
1900-11-200E: Reed switch probe, with 200' measurement tape.
1900-11-300E: Reed switch probe, with 300' measurement tape.

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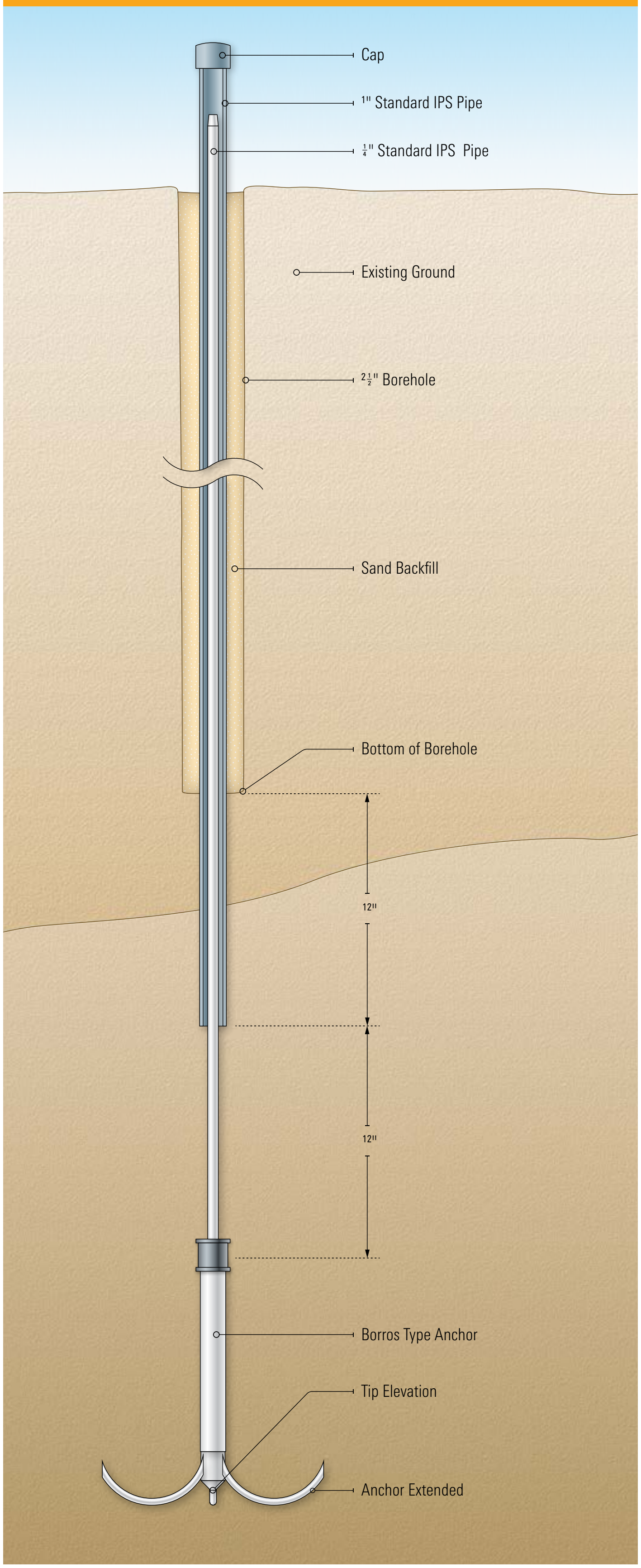
SETTLEMENT POINTS (BORROS TYPE)

MODEL 1950



Typical Heave/Settlement Point Installation.

APPLICATIONS

The Borros Type Settlement Points are designed to measure the settlement of:

- Fills and embankments
- Foundations
- Roadways
- Surcharges

OPERATING PRINCIPLE

The purpose of the heave/settlement points is to measure vertical movements in foundation soils during and subsequent to construction.

The heave/settlement point consists of a three-prong anchor, a ¼" standard inner pipe, and a 1" standard outer pipe. The pipes are assembled in sections and fastened together with standard couplings to the required anchor depths.

The following procedure can be followed for installation of the heave/settlement points:

A cased borehole should be extended to 3' above the anchor tip elevation. Casing may not be required if the borehole can be advanced without caving in. The inside of the casing or borehole should be cleaned to the bottom to remove all loose material.

Next, securely attach the ¼" pipe to the anchor and tighten the 1" pipe to the greased left-hand thread of the anchor. Additional pipe sections are added as the complete assembly is lowered into the borehole. The anchor is then driven or pushed with the 1" pipe to the elevation desired.

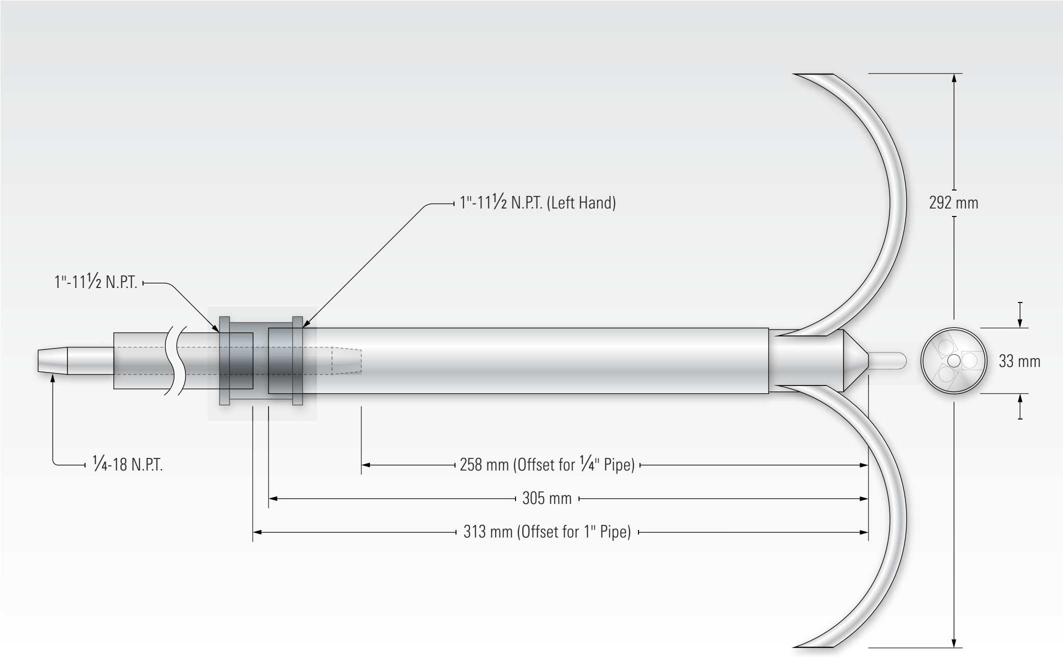
The 1" pipe is then secured in position. With the 1" pipe clamped, the ¼" pipe can be advanced hydraulically by the drilling machine or driven by hand for approximately 7" relative to the 1" pipe. This operation will extend the anchor prongs and secure it in the soil.

Detach the 1" pipe from the anchor by turning the pipe in a clockwise direction for at least 15 complete revolutions.

The 1" pipe can then be raised high enough to clear the ¼" inner pipe, to its final position, and capped.

Withdraw casing from the borehole and backfill the annular space around the 1" pipe with clean sand.

Model 1950 Settlement Point with Borros Type Anchor.



Model 1950-1 dimensions.

ADVANTAGES AND LIMITATIONS

For settlement point installations, as the fill continues to rise, sections of 1" and ¼" pipe are added to maintain the top of the pipe between 1' and 5' above the surface of the fill.

The materials surrounding the 1" pipe must be hand placed to avoid damaging the installation.

The 1" pipe should be capped at all times except when readings or extensions are being accomplished.

ORDERING INFORMATION

Model 1950-2: ¼" × 3' long[1] SCH40 Galvanized Steel Pipe, male threaded both ends.

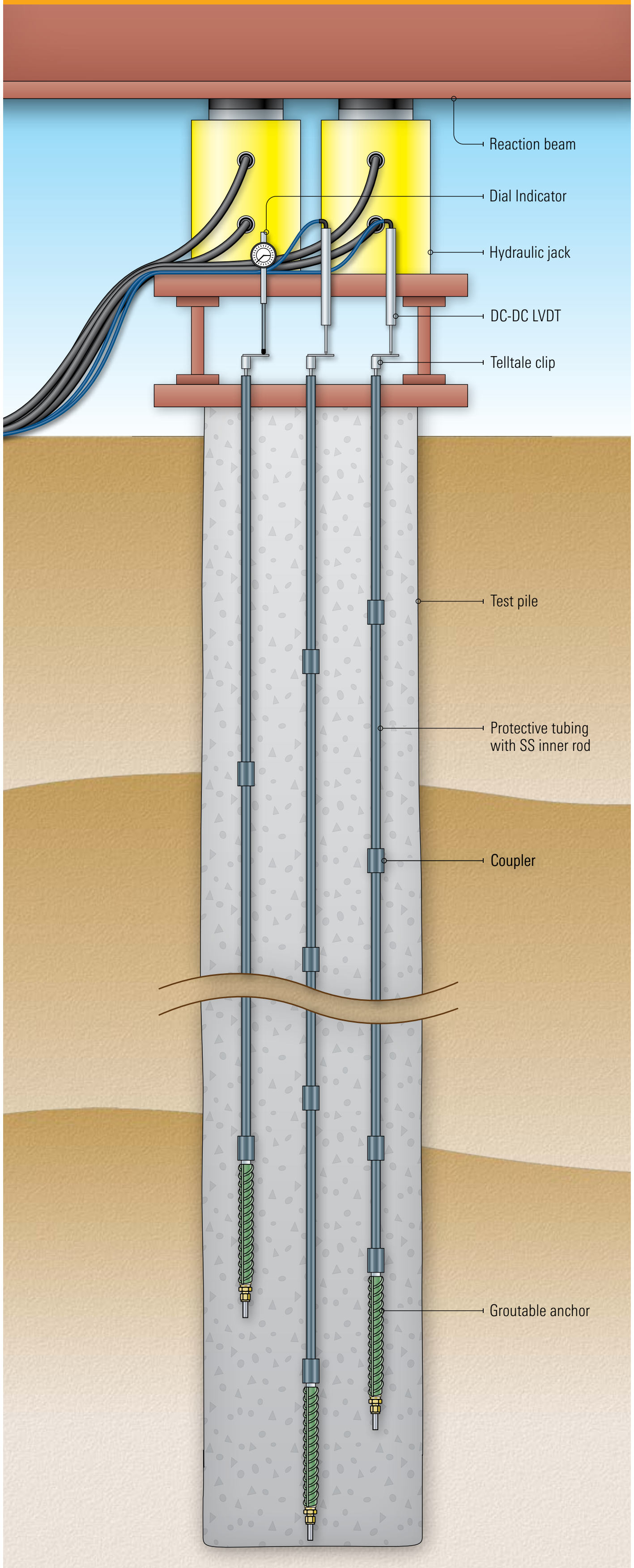
Model 1950-3: 1" × 3' long[1] SCH40 Galvanized Steel Pipe, male threaded both ends.

[1] Custom pipe lengths are available on request: please contact GEOKON for details.

TELLTALES

GEOKON

MODEL 1800



Model 1800 Telltale installation, as used for static load testing of a pile.

APPLICATIONS

Telltales are often used to measure the pattern of load transfer in:

- Piles
- Drilled shafts
- Tieback Anchors
- Information on pile tip movements and deflections along the pile.

OPERATING PRINCIPLE

Telltales are commonly used in piles subjected to Static Load Tests, the results of which provide information used to confirm (or refine) the design of deep foundations. Static load testing applies load incrementally to a deep-foundation element, while measuring foundation movement.

In static axial compression and tension load tests, applied loads are determined using a load cell or hydraulic jack pressure and the head movement is measured using digital or mechanical dial gauges, or displacement transducers. The applied load vs. head movement is plotted and interpreted to define the foundation's geotechnical failure. Additionally, embedded instrumentation consisting of strain gauges or telltales can be added to measure foundation strain, from which the load in the foundation can be estimated. The resulting load transfer profiles present load in, and resistance along, the foundation's length, as well as unit toe resistance. This information is used to refine static analysis methods and calibrate dynamic pile monitoring results.

ADVANTAGES AND LIMITATIONS

One of the major advantages of the telltale system is the fact that the telltale rods can be inserted into protective tubing after the pile has been driven or cast, thus reducing the likelihood of damage. This configuration also allows the telltale rods to be removed after testing is complete and reused on subsequent tests.

The analysis of telltale measurements depends primarily on the precision of the measurements and how accurately the area and modulus are known. Furthermore, telltale data intended for load distribution analysis must be obtained with an accuracy much greater than that normally used for measurements in static load tests, typically, the minimum sensitivity required is 0.0005" (0.01 mm).

Groutable Anchor

Model 1150-42 Telltale clip

Model 1400-1 Dial indicator

Model 1450 DC-DC LVDT

SYSTEM COMPONENTS

A telltale normally consists of a protective tube extended to a steel plate or rebar anchor, which is embedded inside a concrete pile, or welded onto steel piles at various locations along the pile length.

To measure the deflection at the tip, the telltale must be anchored to the pile by the steel plate or rebar, but isolated from the pile grout everywhere else. This is done by placing the telltale rods inside protective tubing and sealing the ends. Sometimes the annular space is filled with grease other compound for lubrication and to prevent grout intrusion. If the telltale rod is not isolated from the grout by the sleeve, it will not function correctly.

The movement of the top of each telltale, relative to the top of the pile is measured with a dial gauge having 0.001" (0.25 mm) sensitivity. Alternatively, electronic displacement transducers, with similar sensitivity can be used.

Telltale clips, secured to the tip of each telltale rod facilitate ease of readout when using dial gauges.

Normally, telltale readings are referenced to the top of the pile. By noting the location of the specific telltale anchor and measuring the relative movement of the individual rod, elastic shortening of the pile at that location can be obtained. With this information, the load (Q) in the pile at the midpoint between two telltale anchors, separated by a distance L can be obtained using $Q = A(\Delta L/L)E$, where A = the cross sectional area of the pile and E= the modulus.

ORDERING INFORMATION

ROD-101: Flush coupled 6 mm (0.25") Ø SS rod
ROD-103: Flush coupled 6 mm (0.25") Ø graphite rod
ROD-105: Flush coupled 6 mm (0.25") Ø 1018 mild steel rod
TUB-101: 6 mm (0.25") Ø SCH 40 PVC tube
TUB-160: 6 mm (0.25") Ø SCH 80 PVC tube
1150-13: Groutable anchor with bayonet type attachment
1100-GROUTABLE: Groutable anchor
1150-41: Plate anchor
1150-42: Telltale clip
1400-1-2: Dial indicator, in carrying case, English dial, 2" range
1400-1-4: Same as above, 4" range
1400-1-6: Same as above, 6" range
1400-2-2: Dial indicator, in carrying case, metric dial, 50 mm range
1400-2-4: Same as above, 100 mm range
1400-2-6: Same as above, 125 mm range
1450-2: DC-DC, blind end style, 2" (50 mm) range
1450-4: Same as above, 4" (100 mm) range
1450-6: Same as above, 6" (150 mm) range
1450-7: DC-DC mounting brackets
1450-8: DC-DC swivel post and magnetic base

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48 Spencer Street
Lebanon, NH 03766·USA

www.geokon.com
e: info@geokon.com
p: +1·603·448·1562

RETRIEVABLE EXTENSOMETER

GEOKON®

MODEL 1300 (A-9)

Model 1300 (A-9) Retrievable Extensometer bottom anchor (front), transducer with anchor (middle two), and connecting rod (rear).

APPLICATIONS

The Model 1300 (A-9) Retrievable Extensometer is designed for the measurement of deformations in boreholes and is particularly suited for use in load testing of concrete piles. Borehole deformation can be measured in:

- Piles
- Concrete
- Rock
- Other materials

OPERATING PRINCIPLE

The Model 1300 (A-9) Retrievable Extensometer is designed for the measurement of extensions and contractions along boreholes in the ground or in concrete. It is particularly useful in concrete pile testing where it can be installed inside a PVC or steel pipe cast in the pile: in this application it is a substitute for either tell-tales or strain gauges. A primary feature of the Model 1300 (A-9) is its ability to be retrieved and used repeatedly.

In use, the extensometer incorporates a string of electronic displacement sensors linked together by extension rods and designed to measure the relative displacement between a series of pneumatically expandable anchors. The string of sensors is assembled (with variable lengths of connecting rods to enable positioning of the anchors at the required depths), inserted into the pipe or borehole, and then locked in position by pneumatically actuating the various anchors, which remain fully expanded throughout the monitoring period. When monitoring has been completed, the pneumatic pressure is released which retracts the anchor pistons and allows removal of the string for further use.

ADVANTAGES AND LIMITATIONS

The displacements are measured over specific increments, eliminating the inaccuracies associated with Tell-Tales or Multiple Position Borehole Extensometers, where measurements of inter-anchor strains are calculated from the difference between two long base measurements from the surface to each of the anchor points in question. When used as a substitute for strain gauges, the measured distance is longer; hence, the Retrievable Extensometer integrates the strains over a larger and possibly more representative sample than would be obtained using strain gauges.

The ability to retrieve and re-use the Model 1300 (A-9) can result in significant cost savings where repeated tests are required that would otherwise use either non-retrievable extensometers or strain gauges.

High accuracies can be achieved using a variety of sensor types with various available ranges.

The design of the anchors requires the use of borehole or pipe sizes, which are closely controlled.

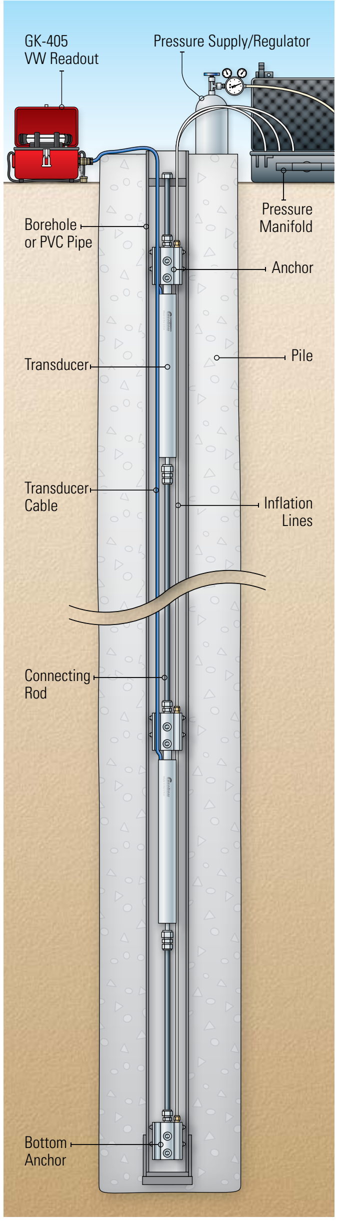

Illustration shows a typical Model 1300 (A-9) installation in a concrete pile.

SYSTEM COMPONENTS

The standard system is designed for a maximum of eight anchor/sensor segments. Each anchor contains eight pistons, which can be pneumatically actuated to force them out against the sides of the borehole. The pistons are spring-loaded and automatically retract when the pressure is removed. A pressure manifold, containing on/off valves and check-valves, connects to each of the inflation lines leading to the anchors, enables each of the anchors to be actuated in turn, and maintains the anchor pressure during the monitoring period. Gas pressure is obtained from a pressurized nitrogen bottle.

Each anchor is attached to a vibrating wire sensor (or, optionally, to a DC-DC LVDT or linear potentiometer sensor) and can be linked to adjacent anchors by means of Swagelok fittings that grip the interconnecting rods. These rods can be adjusted to various lengths using a hacksaw. Rods may be made from fiberglass, stainless steel or carbon graphite.

Readout is accomplished by connecting cables from each sensor to Model GK-404 or GK-406 Readouts. Switch panels or Multiplexers (Model 8032) are available to rapidly switch through all the active sensors.

TECHNICAL SPECIFICATIONS

Standard Range[1]	12.5, 25, 50, 100, 150, 200 mm 0.5, 1, 2, 4, 6, 8 in
Resolution	0.025% F.S.
Accuracy[2]	±0.1% F.S.
Temperature Range[1]	+10 °C to +60 °C
Number of Anchors	2 min–8 max
Materials	Stainless steel anchors and transducers
Connecting Rods	Graphite, fiberglass, stainless steel
Cable	4-conductor shielded
Borehole Diameter	46–53 mm
Diameter	Anchor: 45 mm Transducer:25 mm
Overall Length	495 mm

[1]Other ranges available on request.
[2]Accuracy established under laboratory conditions.
Note: the Model A-9 Retrievable Extensometer was awarded Patent No. 5,585,555 in 1996 by the USPTO.

Model 1300-3 Pressure Manifold.

Model GK-406 Vibrating Wire Analyzer.

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48 Spencer Street
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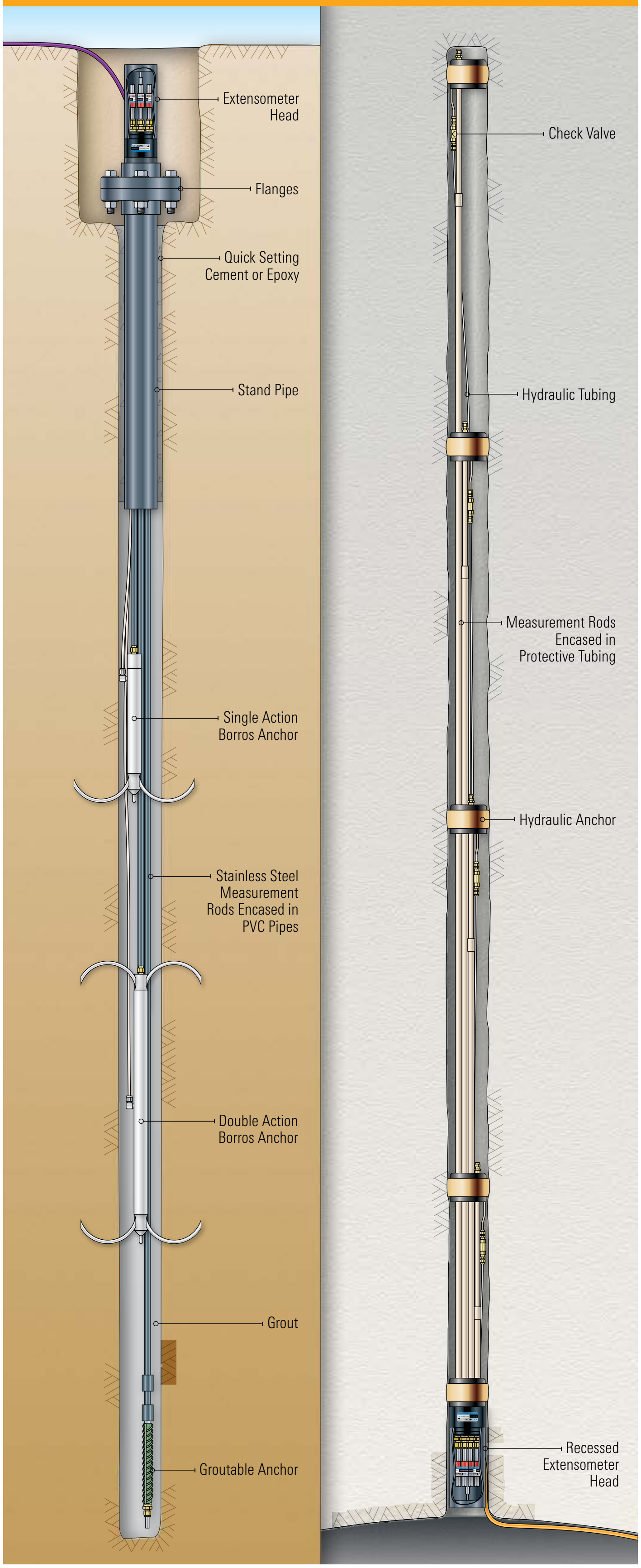
www.geokon.com
e: info@geokon.com
p: +1·603·448·1562

ROD TYPE BOREHOLE EXTENSOMETERS

GEOKON®

MODEL 1100



Flange type Model 1100 Extensometer with Borros and Rebar borehole anchors (left) and Flangeless type with bladder anchors (right).

APPLICATIONS

Typical applications include the measurement of:

- Ground movements around tunnels
- Deformation of dam abutments and foundations
- Fracturing in the roofs and walls of underground caverns
- Ground movements in the walls of open pit mines
- Ground movement behind retaining walls, sheet piling, slurry walls, etc.
- Subsidence above tunnels and mine openings
- Settlement and heave of foundations in soft soil

OPERATING PRINCIPLE

Rod Type Borehole Extensometers utilize measurement rods to connect sensors inside the head of the extensometer to anchors installed in the borehole. Movement of the anchors in relationship to the head of the extensometer, which is anchored at the mouth of the borehole, can be analyzed to reveal the magnitude of the deformation between the anchors.

Readout is achieved by connecting the head of the extensometer to a portable readout, datalogger, or similar device.

ADVANTAGES AND LIMITATIONS

Model 1100 Rod Type Borehole Extensometers allow up to six anchor points to be secured along the axis of the borehole, in soil, rock, or concrete, to measure longitudinal displacements at each anchor location.

There are two main types of extensometer head. The Flange type is designed to sit on the surface of the rock, soil or concrete structure at the mouth of the borehole. The Flangeless type is designed to be recessed into the borehole or into an enlarged section of the borehole. This can provide protection from traffic, vandalism, blasting, construction activity, etc.

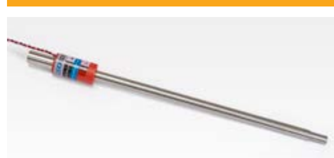
Two types of measurement rods are available, stainless steel and fiberglass.[1] The stainless steel type is assembled on site according to customer-specific anchor depths, whereas the lighter fiberglass rod type is delivered preassembled to facilitate installation. The measurement rods are encased in protective tubing ensuring they are isolated from grout and debris and allowed to move freely with the anchors.

A variety of anchor types are available for use in soil and rock, and in grouted and non-grouted installations.

Movement of the measurement rods in relationship to the head of the extensometer is sensed electronically using the requisite number of Model 4450 Vibrating Wire Transducers.[2]

[1] Other rod types, including Invar and Carbon Graphite (for use where temperature effects need to be minimized) are available on request.
[2] Other readout types including linear potentiometers, DCDTs and manual readouts are available on request.

MODEL 4450 VIBRATING WIRE DISPLACEMENT TRANSDUCERS



Model 4450 VW Displacement Transducer

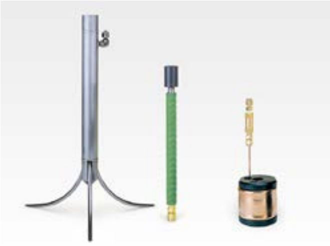
The Model 4450 VW Displacement Transducer provides remote readout for Model 1100 Extensometers. VW transducers are especially beneficial in locations where other vibrating wire sensors are used or where long cable runs are required.

MODEL 4450 TECHNICAL SPECIFICATIONS

Standard Ranges[1]	12.5, 25, 50, 100, 150, 200, 300 mm
Resolution	0.025% F.S.
Accuracy[2]	±0.1% F.S.
Nonlinearity	< 0.5% F.S.

[1] Other ranges available on request. [2] Accuracy established under laboratory conditions. [3] Transducer only

ANCHORS



Model 100-S-BORROS, 1100-GROUTABLE and 1100-BLADDER anchors (left to right)

Three anchor types are available[3] and multiple anchor types may be used on a single extensometer, if required.

GROUTABLE ANCHORS

Groutable anchors, constructed from lengths of steel reinforcing bar, are the preferred option for installation in downward directed boreholes that are easily filled with cement grout.

HYDRAULIC BORROS ANCHORS

Hydraulic Borros Anchors are recommended for soft soils. These feature a set of curved prongs spaced 120° apart, which are recessed within the anchor body until activated. Under hydraulic pressure the prongs (3 on single action anchors, 6 on double action anchors) extend 150 mm from the anchor body and into the borehole wall.

HYDRAULIC BLADDER ANCHORS

Hydraulic bladder anchors can be easily installed in boreholes oriented in any direction. They are particularly useful in boreholes which are fractured, oriented upwards, or difficult to grout. They consist of a copper bladder wrapped around a spool of high strength plastic. Attached to the copper bladder is a high pressure nylon inflation line and check valve. The inflation is accomplished with a hydraulic pump causing the copper bladder to expand and “unwind,” and permanently deform so that the grip is not lost even if the check valve fails.

Bladder anchors are custom sized for each borehole and accommodate up to 30 mm of oversize without loss of grip.

[3] Snap ring anchors are available on request. They are designed for boreholes also in hard or competent rock, with a smooth wall and uniform diameter. Snap ring anchors are installed using setting rods to push to the required depth. A pull cord is used to remove the locking pin, which activates two retaining rings that snap outward and grip the borehole.

ROD TYPES

Extensometer rods are available in continuous lengths of fiberglass, or in 3 m or 1.5 m lengths of flush coupled 303 stainless steel.

ROD PROPERTIES

Material	Diameter	Weight/Meter	Young's Modulus	Temp. Coefficient
303 Stainless Steel	6 mm	0.25 Kg/m	200 GPa	17.5 ppm/°C
Fiberglass	6 mm	0.06 Kg/m	20 GPa	3.0 ppm/°C

Rod Length Tolerances	0-1.5 m	1.5-3 m	3-6 m	6-30 m	30+ m
303 Stainless Steel	±1.5 mm	±6.3 mm	n/a	n/a	n/a
Fiberglass	±1.5 mm	n/a	±6.3 mm	±12.7 mm	±25.4 mm

TUBE TYPES

Three protective tube types are available: PVC for use with stainless steel rods and polyethylene and/or nylon for the fiberglass rod type.

Where extensometers are used to measure settlement (compression) slip couplings are available to accommodate the shortening of the rod/tube columns. This is especially important if more than 25 mm of compression is expected.

TUBE PROPERTIES

Model #	Material Type	I.D.	O.D.	Wall Thickness	Collapse Pressure
TUB-101	Schedule 40 PVC	9.2 mm	13.9 mm	2.2 mm	5,378 kPa
TUB-103	Polyethylene	9.5 mm	12.7 mm	1.6 mm	931 kPa
TUB-109	Nylon	9.5 mm	12.7 mm	1.6 mm	1,724 kPa

ORDERING INFORMATION

1100-1:* Head assembly for rod type extensometers, 1 measurement point. Minimum borehole ID = 73 mm.
1100-2:* Head assembly for rod type extensometers, 2 measurement points. Minimum borehole ID = 73 mm.
1100-3:* Head assembly for rod type extensometers, 3 measurement points. Minimum borehole ID = 89 mm.
1100-4:* Head assembly for rod type extensometers, 4 measurement points. Minimum borehole ID = 89 mm.
1100-5:* Head assembly for rod type extensometers, 5 measurement points. Minimum borehole ID = 114 mm.
1100-6:* Head assembly for rod type extensometers, 6 measurement points. Minimum borehole ID = 114 mm.
1100-KIT: Installation kit with extension rods. Specify measurement points and transducer range. (Number of kits required equals maximum number of extensometers to be installed in a single day.)
1100-COUPLING: PVC standpipe, 0.75 m long, with coupling. Specify number of measurement points.
1100-FLANGE: PVC standpipe, 0.75 m long, with flange. Specify number of measurement points.
1100-GROUTABLE: Groutable anchor. Specify rod type.
1100-BLADDER: Hydraulic bladder anchor with check valve. Specify measurement points and rod type.
1100-S-BORROS: Hydraulic Borros type anchor, single action. Specify rod type.
1100-D-BORROS: Hydraulic Borros type anchor, double action. Specify rod type.
1100-PUMP: Hydraulic pump with quick connect for inflating hydraulic anchors.
1100-SLIP-10CM: Inline slip coupling, 10 cm range. Specify rod type.
1100-SLIP-30CM: Inline slip coupling, 30 cm range. Specify rod type.
1100-GROUT-DOWN: Set of grouting acces- sories for inclined downwards installations.
1100-GROUT-UP: Set of grouting accessories for overhead/upward installations. Note: One set may be required per overhead extensometer.
1100-TOOLKIT: Set of installation tools.
1100-RECESSED-TOOLS: Additional tools required for recessed installations.
1100-UPWARD-TOOL: Additional tools required for upward installations.
ROD-101: Flush coupled SS rod, 6 mm Ø.
ROD-104: Continuous fiberglass rod, 6 mm Ø.
TUB-101: Schedule 40 PVC tubing, 6 mm Ø.
TUB-103: Polyethylene tubing, 13 mm Ø. For use with 6 mm Ø fiberglass rod at anchor depths <30 m.
TUB-104: Grout tube, 19 mm Ø.
TUB-105: Polyethylene vent tube, 6 mm Ø.
TUB-108: Nylon pressure tube, 5 mm Ø.
TUB-109: Nylon tubing, 13 mm Ø. For use with 6 mm Ø fiberglass rod at anchor depths >30 m.
4450-1: VW Displacement Transducer for use with Rod Type Borehole Extensometers. Specify range: 12.5, 25, 50, 100, 150, 200, 300 mm
02-250V6: Blue PVC cable, 6.35 mm (±0.25 mm) [0.250"] Ø, 2 twisted pairs, for single point extensometers.
02-250P9LT: Purple polyurethane cable, 6.35 mm (±0.25 mm) [0.250"] Ø, 2 twisted pairs, for single point extensometers.
04-375V9: Violet PVC cable, 9.50 mm (±0.38 mm) [0.375"] Ø, 4 twisted pairs, for 2 and 3 point extensometers.
05-375V12: Tan PVC cable, 9.50 mm (±0.38 mm) [0.375"] Ø, 5 twisted pairs, for 4 point extensometers.
06-500V7: Orange PVC Cable, 12.70 mm (±0.38 mm) [0.500"] Ø, 6 twisted pairs, for 5 point extensometers.
12-625V5: Brown PVC cable, 15.90 mm (±0.38 mm) [0.625"] Ø, 12 twisted pairs, for 6 point extensometers.

**Specify rod type and transducer range.*

PT GLOBAL TEKNIK PASUNDAN

SOLUSI TEKNIK

GEOKON INCLINOMETER

Category: Instrumentasi Geoteknik - Inclinometer

globalteknikpasundan.com

VERTICAL IN-PLACE INCLINOMETER SYSTEM

GEOKON®

MODEL 6180

Model 6180 Biaxial MEMS Tilt Sensors.

APPLICATIONS

The remote, continuous, and automatic monitoring of:

- Lateral deformation in dams and tailings
- The stability of natural slopes, landslides, embankments, and subsea marine sediments
- The stability of slurry walls, sheet piling and tieback walls
- Lateral movements in, around and above tunnels and underground openings

OPERATING PRINCIPLE

The basic principle of operation is the utilization of MEMS (Micro-Electro-Mechanical Systems) tilt sensors to make accurate measurements of inclination over segments of a borehole drilled into the structure being studied.

The Model 6180 Vertical In-Place Inclinometer System consists of a string of Biaxial MEMS Tilt Sensors, installed in sections of stainless tubing, which are manufactured to customer-selected lengths. Spring-loaded wheel assemblies, located between each segment, allow the string to positively engage the grooves of the conventional inclinometer casing[1] in which it is installed. The entire string is normally supported from the top of the casing by a suspension bracket, although installations where the string sits on the bottom of the casing are also possible.

Each segment in the inclinometer string is mechanically connected with quick-connect ball joints and electrically connected by means of waterproof connectors on a four-wire bus cable. The cable from the uppermost sensor connects the string to the chosen readout (PC, datalogger, SCADA system, etc.).

The output from each string consists of calibrated tilt readings and temperatures for each sensor, which can be easily imported into MS Excel, or any inclinometer visualization software, without the need to convert raw data into engineering units.

[1] Fits any standard casing with groove diameter from 58 mm to 90 mm.

ADVANTAGES

MEMS tilt sensors operate over a wide angular range, with high sensitivity, and excellent long-term stability. In addition, their low profile and low mass makes them very resistant to shock loads.

Digital inclinometer systems offer greater noise immunity than analog types and are capable of signal transmission over cable lengths up to 1200 m, depending on the number of sensors in the string.

Other advantages of automated In-Place Inclinometer readings include the ability for increased frequency of readings, which can be critical for online (real-time) monitoring applications.

Addressable In-Place Inclinometer systems also allow the user to optimize the spatial resolution within the borehole by allowing for different gauge lengths in the same string.

DATA ACQUISITION

The Model 6180 Vertical In-Place Inclinometer System uses industry standard Modbus® Remote Terminal Unit (RTU) protocol to communicate. It employs an RS-485 (half duplex) electrical interface, recognized for its prevalence, simplicity, and success as a robust, industrial physical layer.

Monitoring can be accomplished using GeoNet Addressable Loggers, the Model 8020-38 Addressable Bus Converter, Model 8600 Series Dataloggers, Campbell Scientific Dataloggers, or any other device capable of operating as a Modbus RTU client and having an RS-485 port.

TECHNICAL SPECIFICATIONS

Range[1]	±90°	Standard Sensor Length[6]	0.5m, 1m, 2m, 3m, 2ft, 5ft, 10ft
Resolution[2]	0.00025° (0.004 mm/m)	Sensor Weight	0.5m: 0.55kg (1.22lb), 1m: 0.97kg (2.14lb), 2m: 1.80kg (3.98lb), 3m: 2.64kg (5.82lb), 2ft: 0.64kg (1.42lb), 5ft: 1.40kg (3.10lb), 10ft: 2.67kg (5.90lb)
Precision[3]	±0.0075° (±0.13 mm/m)	Materials	316 Stainless Steel, Engineered Polymer
Nonlinearity	±0.005° across ±30° range (±0.09 mm/m)	Electrical Cable	Four Conductor, Foil shield, Polyurethane jacket, nominal OD = 7.9 mm
Temperature Dependent Uncertainty	±0.001° across ±5° range (±0.016 mm/m) ±0.0016° across ±15° range (±0.026 mm/m) ±0.0026° across ±30° range (±0.042 mm/m)	Minimum Sensor Spacing	0.5 m
Operating Temperature	−40 °C to 65 °C (−40 °F to 149 °F)	Interface	RS-485
Power Supply Voltage	12 VDC ±20%	Protocol	MODBUS
Operating Current[4]	12 mA ±1 mA	Baud Rate	115,200 bps
Standby Current[4]	2 mA ±0.1 mA	Temperature Accuracy	±0.5 °C
Maximum Supply Current[5]	500 mA	Ingress Protection	IP68 to 3MPa (300m head water)
Sensor Diameter	25.4 mm (1")	Maximum Allowable String Weight	272 kgf (600 lbf)

[1] Calibrated Range: ±30°
[2] 99% confidence interval (i.e. 99 out of 100 individual readings fall within this tolerance).
[3] Includes random walk (changes between consecutive readings that have no discernible cause) and seismic noise during testing.
[4] Operating and standby current are for each individual sensor in a string.
[5] Per entire string.
[6] Custom spacing available upon request.

ORDERING INFORMATION

6180-0.5M: MEMS Digital In-Place Addressable Inclinometer, Vertical, Biaxial, sensor for 0.5 m spacing
6180-1M: as above, 1 m spacing
6180-2M: as above, 2 m spacing
6180-3M: as above, 3 m spacing
6180-2FT: as above, 2 ft. spacing
6180-5FT: as above, 5 ft. spacing
6180-10FT: as above, 10 ft. spacing
6180T-0.5M: MEMS Digital In-Place Addressable Inclinometer, Vertical, Biaxial, terminal sensor for 0.5 m spacing
6180T-1M: as above, 1 m spacing
6180T-2M: as above, 2 m spacing
6180T-3M: as above, 3 m spacing
6180T-2FT: as above, 2 ft. spacing
6180T-5FT: as above, 5 ft. spacing
6180T-10FT: as above, 10 ft. spacing
6180-1: Suspension Cable Assembly, connects suspension bracket to top sensor, specify required length
6180-2: Suspension Bracket, sits atop casing
6180-3-1: Readout Cable, lengths <15 m (50 ft.), bare leads
6180-3-2: as above, 16 to 30 m (50 to 100 ft.)
6180-3V: as above, lengths >30 m (100 ft.)
6180-6: Safety Cable Assembly, secures bottom sensor to stable point above ground, specify required length

**Each string comprises a customer-specified number of 6180 sensors (including one 6180T sensor), and one of each of the following: 6180-1, 6180-2, 6180-3, 6180-6.*

LEGACY VERSIONS

Limited legacy versions are available allowing for the repair and/or expansion of retired, previously available GEOKON In-Place Inclinometer models. Please contact GEOKON for more information.

COMPATIBLE READOUTS AND DATALOGGERS

8600 Series: Multi-Channel Dataloggers
8800 and 8900 Series: GeoNet Wireless Data Acquisition System
8920, 8930, 8950 Series: GeoNet Cellular, Wi-Fi, and Satellite Network Loggers
8940: GeoNet Dataloggers
8020-38: Addressable Bus converter

Model 6180 Vertical In-Place Inclinometer.

HORIZONTAL IN-PLACE INCLINOMETER SYSTEM

GEOKON®

MODEL 6185

Model 6185 Biaxial MEMS Tilt Sensors.

APPLICATIONS

The remote, continuous, and automatic monitoring of:

- The stability of structures, underground openings, and foundations
- The stability of tank foundations and subway tunnels
- Ground movements and differential settlements in, around and above tunnels and underground openings

OPERATING PRINCIPLE

The basic principle of operation is the utilization of MEMS (Micro-Electro-Mechanical Systems) tilt sensors to make accurate measurements of inclination over segments of an inclinometer casing installed under the structure being studied.

The Model 6185 Horizontal In-Place Inclinometer System consists of a string of Biaxial MEMS Tilt Sensors, installed in sections of stainless steel tubing, which are manufactured to customer-selected lengths (see table on next page).

Spring-loaded wheel assemblies, located between each segment, allow the inclinometer to positively engage the vertically oriented grooves of the inclinometer casing[1] in which it is installed. The entire string is normally affixed to the end of the casing by a mounting bracket.

Each segment in the inclinometer string is mechanically connected with quick-connect ball joints and electrically connected by means of waterproof connectors on a four-wire bus cable. The cable from the outermost sensor connects the string to the chosen readout (PC, datalogger, SCADA system, etc.).

The output from each string consists of calibrated tilt readings and temperatures for each sensor, which can be easily imported into MS Excel, or other inclinometer visualization software, without the need to convert raw data into engineering units.

[1] Fits any standard casing with groove diameter from 58 mm to 90 mm.

ADVANTAGES

MEMS tilt sensors operate over a wide angular range, with high sensitivity, and excellent long-term stability. In addition, their low profile and low mass makes them very resistant to shock loads.

Digital inclinometer systems offer greater noise immunity than analog types and are capable of signal transmission over cable lengths up to 1200 m, depending on the number of sensors in the string.

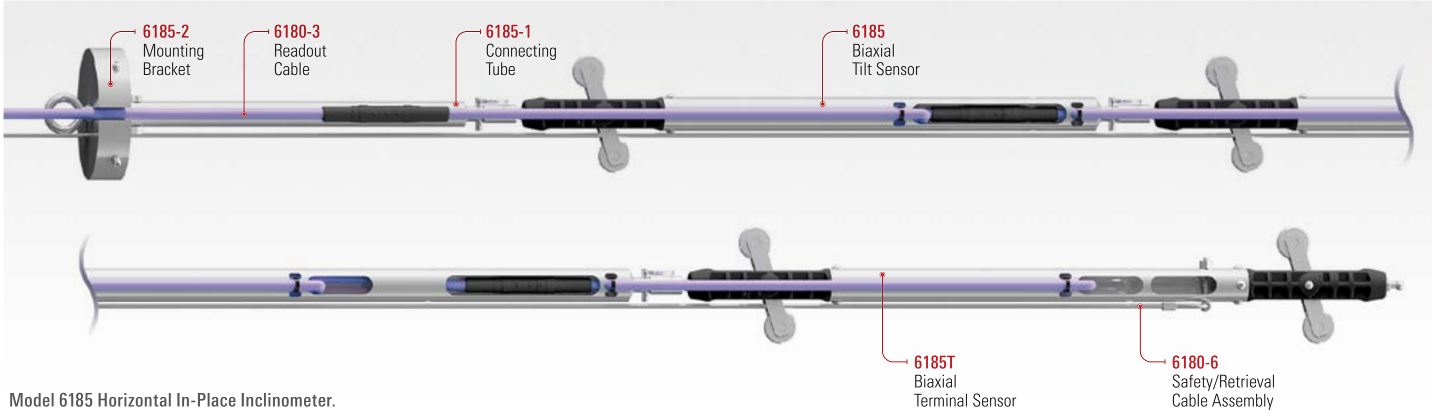
Other advantages of automated In-Place Inclinometer readings include the ability for increased frequency of readings, which can be critical for online (real-time) monitoring applications.

Addressable In-Place Inclinometer systems also allow the user to optimize the spatial resolution by allowing a combination of different gauge lengths in the same string.

DATA ACQUISITION

The Model 6185 Horizontal In-Place Inclinometer System uses industry standard Modbus® Remote Terminal Unit (RTU) protocol to communicate, in particular. It employs an RS-485 (half duplex) electrical interface, recognized for its prevalence, simplicity, and success as a robust, industrial physical layer.

Monitoring can be accomplished using GeoNet Addressable Loggers, the Model 8020-38 Addressable Bus Converter, Model 8600 Series Dataloggers, Campbell Scientific Dataloggers, or any other device capable of operating as a Modbus RTU client and having an RS-485 port.



Model 6185 Horizontal In-Place Inclinometer.

TECHNICAL SPECIFICATIONS

Range[1]	±90°
Resolution[2]	0.00025° (0.004 mm/m)
Precision[3]	±0.0075° (±0.13 mm/m)
Nonlinearity	±0.005° across ±30° range (±0.09 mm/m)
Temperature Dependent Uncertainty	±0.001° across ±5° range (±0.016 mm/m) ±0.0016° across ±15° range (±0.026 mm/m) ±0.0026° across ±30° range (±0.042 mm/m)
Operating Temperature	−40 °C to 65 °C (−40 °F to 149 °F)
Power Supply Voltage	12 VDC ±20%
Operating Current[4]	12 mA ±1 mA
Standby Current[4]	2 mA ±0.1 mA
Maximum Supply Current[5]	500 mA
Sensor Diameter	25.4 mm (1")
Standard Sensor Length[6]	0.5m, 1m, 2m, 3m, 2ft, 5ft, 10ft
Sensor Weight	0.5m: 0.55kg (1.22lb), 1m: 0.97kg (2.14lb), 2m: 1.80kg (3.98lb), 3m: 2.64kg (5.82lb), 2ft: 0.64kg (1.42lb), 5ft: 1.40kg (3.10lb), 10ft: 2.67kg (5.90lb)
Materials	316 Stainless Steel, Engineered Polymer
Electrical Cable	Four Conductor, Foil shield, Polyurethane jacket, nominal OD = 7.9 mm
Minimum Sensor Spacing	0.5 m
Interface	RS-485
Protocol	MODBUS
Baud Rate	115,200 bps
Temperature Accuracy	±0.5 °C
Ingress Protection	IP68 to 3MPa (300m head water)

[1] Calibrated Range: ±30°
[2] 99% confidence interval (i.e. 99 out of 100 individual readings fall within this tolerance).
[3] Includes random walk (changes between consecutive readings that have no discernible cause) and seismic noise during testing.
[4] Operating and standby current are for each individual sensor in a string.
[5] Per entire string.
[6] Custom spacing available upon request.

ORDERING INFORMATION

6185-0.5M: MEMS Digital In-Place Addressable Inclinometer, Horizontal, Biaxial, sensor for 0.5 m spacing
6185-1M: as above, 1 m spacing
6185-2M: as above, 2 m spacing
6185-3M: as above, 3 m spacing
6185-2FT: as above, 2 ft. spacing
6185-5FT: as above, 5 ft. spacing
6185-10FT: as above, 10 ft. spacing
6185T-0.5M: MEMS Digital In-Place Addressable Inclinometer, Horizontal, Biaxial, terminal sensor for 0.5 m spacing
6185T-1M: as above, 1 m spacing
6185T-2M: as above, 2 m spacing
6185T-3M: as above, 3 m spacing
6185T-2FT: as above, 2 ft. spacing
6185T-5FT: as above, 5 ft. spacing
6185T-10FT: as above, 10 ft. spacing
6185-1-1: Connecting Tube, lengths <1.5 m (5 ft.)
6185-1-2: Connecting Tube, 1.6 to 3 m (5 to 10 ft.)
6185-2: Mounting Bracket
6180-3-1: Readout Cable, lengths <15 m (50 ft.), bare leads
6180-3-2: Readout Cable, 16 to 30 m (50 to 100 ft.)
6180-3V: as above, lengths >30 m (100 ft.)
6180-1: Pulley Cable Assembly, used with dead end pulley assembly for IPI installation, specify required length
6180-6: Retrieval Cable Assembly, facilitates string removal in installations where only one end of the casing is open, specify required length
6550-1-#: Dead End Pulley Assembly, specify casing and return pipe sizes

**Each string is comprised of a customer-specified number of 6185 sensors, and one of each of the following: 6185T, 6185-1, 6185-2, 6180-3*

LEGACY VERSIONS

Limited legacy versions are available allowing for the repair and/or expansion of retired, previously available GEOKON In-Place Inclinometer models. Please contact GEOKON for more information.

COMPATIBLE READOUTS AND DATALOGGERS

8600 Series: Multi-Channel Dataloggers
8800 and 8900 Series: GeoNet Wireless Data Acquisition System
8920, 8930, 8950 Series: GeoNet Cellular, Wi-Fi, and Satellite Network Loggers
8940: GeoNet Dataloggers
8020-38: Addressable Bus converter

GEOKON
48 Spencer Street
Lebanon, NH 03766 · USA

www.geokon.com
e: info@geokon.com
p: +1 · 603 · 448 · 1562

GEOKON is an **ISO 9001:2015** registered company

Not all models are CE approved. Contact GEOKON for details.

VIBRATING WIRE IN-PLACE INCLINOMETER

GEOKON®

MODEL 6300

Model 6300 VW In-Place Inclinometer.

APPLICATIONS

The remote, continuous, and automatic monitoring of:

- The stability of natural slopes, landslides and embankments
- The stability of slurry walls, sheet piling and tie-back walls around excavations
- Lateral ground movements and differential settlements in, around and above tunnels and underground openings

Installation detail with section of Model 6500 Inclinometer Casing removed.

OPERATING PRINCIPLE

The Model 6300 Vibrating Wire In-Place Inclinometer consists of a string of Vibrating Wire tilt sensors mounted on lengths of stainless steel tubing which are linked together by universal joints. A spring-loaded wheel assembly designed to engage the grooves of conventional inclinometer casing is located at each joint. The string of sensors is installed inside the casing with all the sensor cables passing to the surface where they are connected to Terminal Boxes or Dataloggers.

Movements of the ground deflect the casing causing one or more of the inclinometer segments (length L) to undergo changes of inclination ($\Delta\theta$). Summation of all these tilts in the form Σ L sinθ, are plotted to give profiles of lateral deflection. Each tilt sensor contains a thermistor to permit temperatures to be recorded.

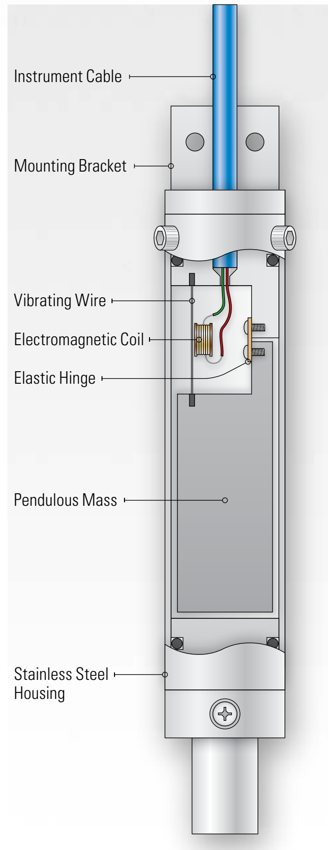
ADVANTAGES & LIMITATIONS

Vibrating Wire tilt sensors have many advantages. They have a wide range combined with high sensitivity, which makes them ideally suited for use in installations which deviate excessively from the vertical. Their long-term stability is excellent and their temperature dependence is close to zero.

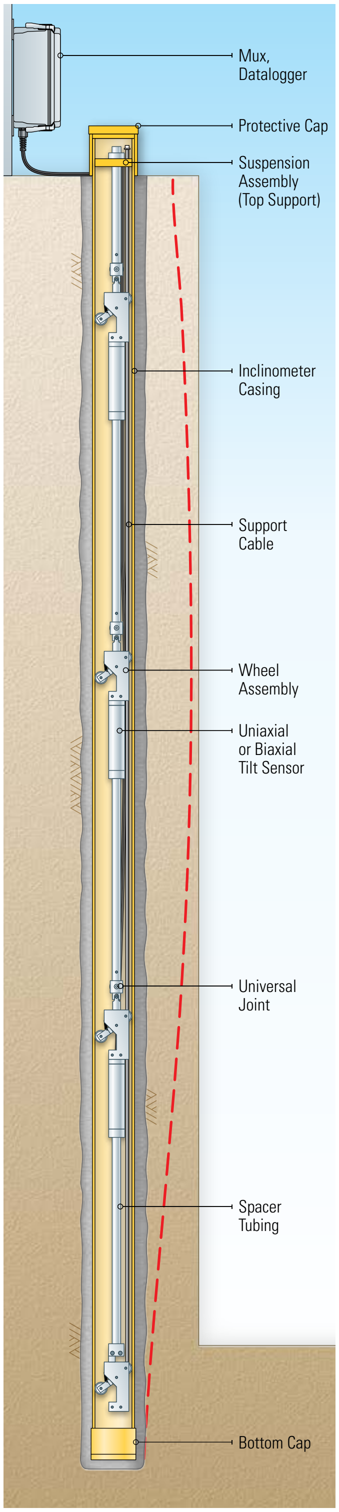
The sensor output is in the form of a varying frequency which can be transmitted over very long cables without loss of accuracy. The simplicity of the design also makes this sensor less susceptible to lightning damage than most others.

Limitations include cost which, even though comparable to or less than other systems, may limit the number of sensors in any one installation. Because of this, the deflection profile obtained may not be as detailed as profiles obtained with conventional inclinometer probes. Costs can be controlled by limiting the tilt sensor placement only to those zones where the largest deflections are anticipated.

The Model 6300 incorporates novel shock absorbers for protection during transportation and installation, but some care in handling is still required.



Vibrating wire tilt sensor construction.



Typical application to monitor the stability of a foundation wall.

SYSTEM COMPONENTS

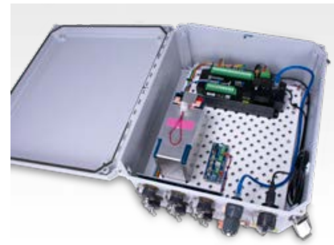
Components of the Vibrating Wire In-Place Inclinometer are shown at left. The tilt sensors may be either uniaxial or biaxial, with wheel assemblies and universal joints separated by spacer tubing of various lengths determined by the required interval between the tilt sensors.

The upper end of the system is suspended from a top support and the lower end requires a special bottom wheel assembly to which a support cable is attached.

For more installation details ask for the Model 6300 In-Place Inclinometer Installation Manual and the Model 6500 Inclinometer Casing Installation Manual.

DATA ACQUISITION

Tilt sensors are read using a Model GK-404 or GK-406 Readout. For automatic monitoring, readout is best accomplished using the Model 8600 Series dataloggers or any other datalogger capable of reading vibrating wire sensors (Campbell Scientific CR1000, Data Electronics Datataker 600, Geomation Model 2380, etc.). Other dataloggers can be accommodated using the GEOKON Single Coil Autoresonant Adapter (SCA).



Model 8600-1 Datalogger.

TECHNICAL SPECIFICATIONS

Standard Range[1]	±10°
Resolution[2]	±0.05 mm/m (±10 arc seconds)
Sensor Accuracy[3]	±0.1% F.S.
Operating Frequency Range	1200-3500 Hz
Plucking Coil Resistance	180 Ω
Materials	Stainless Steel
Electrical Cable	4 conductor Polyurethane jacket, 4.7 mm diameter
Thermal Zero Drift	±0.01% F.S./°C (±4 arc seconds/°C)
Temperature Range[1]	−20 °C to +80 °C
Thermistor Operating Accuracy	±0.5 °C
Waterproof	Tested to 3 MPa
Length × Diameter	187 × 32 mm
Weight	0.9 kg

[1]Other ranges available on request.
[2]Established under laboratory conditions.
[3]Depends on readout equipment.

GLUE-SNAP ABS INCLINOMETER CASING

GEOKON®

MODEL 6400

Close-up shows the Glue-Snap sections of the Model 6400.

APPLICATIONS

Model 6400 Inclinometer Casing is used with all commercially available inclinometer probes to monitor the stability of:

- Embankments
- Slopes
- Rock cuts
- Foundations and excavation walls
- Piles
- Coffer dams

Model 6400 telescoping coupling.

Model 6501-6-2 Inclinometer Casing Protective Housing, 4" galvanized steel pipe with lockable cap.

OPERATING PRINCIPLE

Model 6400 Glue-Snap ABS Inclinometer Casing is used in conjunction with all commercially available inclinometer probes to monitor the stability of embankments, slopes, rock cuts, foundation and excavation walls, piles, coffer dams, etc. Model 6400 Inclinometer Casing is engineered to be assembled quickly and accurately, and used for long and short-term monitoring in the most adverse field conditions. ABS Inclinometer Casing is suitable for installations in boreholes and piles, set into concrete or attached to structures.

The casing and couplings have grooves spaced at ninety-degree intervals, which are designed to maintain the orientation of the probe as it is traversed up and down the casing. The probe accurately measures the change in the angle of tilt, from the vertical, of each portion of the casing. These incremental changes are added together to give a vertical profile of the casing. Changes in the profile become a measure of the stability of the structure.

ADVANTAGES AND LIMITATIONS

GEOKON ABS Inclinometer casing is manufactured using precision CNC technology with non-recycled virgin ABS resin. While more costly than common PVC resin, ABS is preferred due to its superior stability, corrosion resistance and low temperature impact resistance.

The easily assembled casing has high-precision, machined guide grooves so that the inclinometer probe cannot lose its orientation as it passes through the telescoping coupling.

The Glue-Snap integral flush coupling is self-aligning, water-tight and grout-tight. Installation time is minimal and the coupling's external key provides visual and tactile confirmation of proper assembly.

ABS Inclinometer casing cannot exceed temperatures of 80 °C.

The Model 6400 Glue-Snap Inclinometer Casing can accommodate a range of inclinometer sensors including the Model GK-604D Digital Inclinometer System.

Casing anchor.

Grout adapter.

Reconnect adapter and alignment tool.

Bottom plug and top cap.

SYSTEM COMPONENTS

Where heave or settlement is anticipated to exceed 1–2%, telescoping sections must be used to allow axial movement of the casing while minimizing distortion due to vertical strain. Settlement sections must be inserted appropriately extended or collapsed, to accommodate the expected settlement/heave. These sections can accommodate up to 150 mm (6 in.) of compression or heave.

To help prevent damage and vandalism, a lockable protective housing, made from galvanized steel pipe that can be grouted in-place around the top of the casing, is recommended.

TECHNICAL SPECIFICATIONS

Casing	6400-2	6400-3
Casing OD	70 mm (2.75 in.)	85 mm (3.34 in.)
Casing ID	59 mm (2.32 in.)	73 mm (2.87 in.)
Casing Length	1.5 or 3 m (5 or 10 ft.)	1.5 or 3 m (5 or 10 ft.)
Coupling OD	70 mm (2.75 in.)	85 mm (3.34 in.)
Bottom Plug OD	70 mm (2.75 in.)	85 mm (3.34 in.)
Material[1]	ABS Plastic	ABS Plastic
Temperature Range	−30 °C to +80 °C (−22 °F to +176 °F)	−30 °C to +80 °C (−22 °F to +176 °F)
Groove Spiral	< 0.005 Rad/3 m (< 0.3°/10 ft.)	< 0.005 Rad/3 m (< 0.3°/10 ft.)
Weight	1.27 kg/m (0.85 lbs/ft.)	1.49 kg/m (1.00 lbs/ft.)

[1]Tensile modulus = 340,000 psi approximately (per ASTM D638) | Poisson's ratio = 0.35 approximately

ACCESSORIES

Bottom plug: to seal the bottom of the casing.

Top cap: to cover the top of the casing.

Grout adapter: used at the bottom of the casing for depositing grout into the bottom of the borehole through a pipe within the casing. A quick connect fitting on the tremie pipe mates with the grout adapter.

Reconnect adapter and alignment tool: used for reconnecting casing ends that have been sawn off.

Casing anchor: for use with steel or plastic borehole casing. It is attached to the bottom of the Model 6400, which is then pushed inside the borehole casing until the casing anchor emerges, snaps open and engages the ground, thus holding the Model 6400 in place.

ABS-DVW Solvent Cement.

TELESCOPIC CASING SECTION

Casing	6400-2S	6400-3S
Casing OD	77 mm (3.03 in.)	91.4 mm (3.6 in.)
Compressed Length	457 mm (18 in.)	457 mm (18 in.)
Extended Length	609 mm (24 in.)	609 mm (24 in.)
Range	152 mm (6 in.)	152 mm (6 in.)
Weight	0.77 kg (1.7 lbs.)	0.9 kg (2.0 lbs.)

GLUE AND SNAP (70 MM)

Load Test	738 kg (1630 lbs.)
Collapse Test	17.2 bar (250 psi)

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48 Spencer Street
Lebanon, NH 03766 · USA

www.geokon.com
e: info@geokon.com
p: +1 · 603 · 448 · 1562

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INCLINOMETER CASING

GEOKON®

MODEL 6500

Two sections of the Model 6500 Inclinometer Casing shown with a standard length coupling.

APPLICATIONS

The Model 6500 is used with all commercially available inclinometer probes to monitor the stability of:

- Embankments
- Slopes
- Rock cuts
- Foundations and excavation walls
- Piles
- Coffer dams
- Landfills

Close-up shows two sections of the Model 6500 riveted and taped together with a standard length coupling.

Model 6501-6-2 Inclinometer Casing Protective Housing, 4" galvanized steel pipe with lockable cap.

OPERATING PRINCIPLE

The Model 6500 Inclinometer Casing is used in conjunction with all commercially available inclinometer probes to monitor the stability of embankments, slopes, rock cuts, foundation and excavation walls, piles, coffer dams, etc. The casing sections are coupled and grouted inside boreholes, or fixed to the surface of piles or sheet piling. The casing and couplings have grooves spaced at ninety-degree intervals, which fit the wheels of the inclinometer probe thus maintaining the orientation of the probe as it is traversed up and down the casing. The probe accurately measures the change in the angle of tilt, from the vertical, of each portion of the casing. These incremental changes are added together to give a vertical profile of the casing. Changes in the profile become a measure of the stability of the structure.

ADVANTAGES AND LIMITATIONS

The model 6500 Inclinometer Casing is manufactured from pultruded fiberglass, an ideal material, being very strong, lightweight and environmentally resistant. The pultrusion process guarantees there will be no spiraling of the grooves.

Casings and couplers telescope snugly together. This has several advantages: the casings do not need specially machined or molded ends and thus casings can be cut and joined together at any point along their length. Furthermore, connection can still be made even if the ends are damaged. A telescoping joint can easily be made using an extra-long section of coupling, pop-riveted to the casings, using aluminum pop-rivets, to leave a space between the ends of the casings. Both casing and couplings have grooves so that the inclinometer probe cannot lose its orientation as it passes through the telescoping coupling.

Fiberglass casing is resistant to heat and will not deform at temperatures as high as 200 °C (400 °F). It is suitable for use in landfills or for geothermal applications.

The Model 6400 Glue-Snap Inclinometer Casing can accommodate a range of inclinometer sensors including the Model GK-604D Digital Inclinometer System.

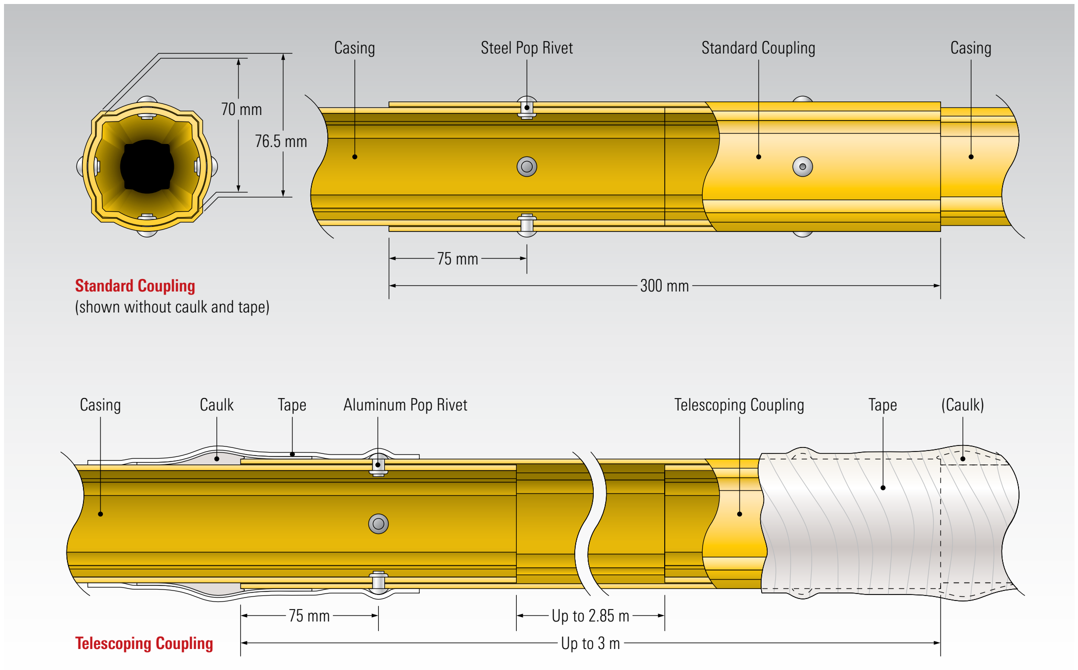

Illustration depicts the Model 6500 Inclinometer Casing dimensions, and configurations of the standard and telescoping couplings.

SYSTEM COMPONENTS

Casings and couplings are pop-riveted together and the joints are water-proofed using caulk and tape.
Steel pop-rivets, ($\frac{1}{8} \times \frac{3}{16}$ inch or $\frac{1}{8} \times \frac{1}{4}$ inch), are standard. Aluminum pop-rivets are used in telescoping couplings, because they are sheared more easily by the telescoping forces.

A bottom plug, pop-riveted and sealed, is used to cap the bottom of the casing and a top plug is used to cap the top of the casing. Lockable protective housings, made from galvanized steel pipe and cement-grouted in-place around the top of the casing, are recommended to help prevent damage and vandalism.

Installation kits, which include caulking, tape, pop-rivets, a pop-rivet gun, and a manual or battery operated hand drill with #30 drill bits, are available.

TECHNICAL SPECIFICATIONS

Maximum O.D. (Nominal)	casing: 70 mm coupling: 76.5 mm
Wall Thickness (Nominal)	casing: 3 mm coupling: 2 mm
Length	casing: 3 m coupling: 300 mm
Telescoping Coupling (specify)	available up to 3 m
Material	Fiberglass
Temperature (Maximum)	200 °C (400 °F)
Collapsing Pressure[1]	1.4 MPa (200 psi)
Weight	1.1 kg/m (0.74 lbs/ft.)

[1]Maximum recommended pressure differential (O.D. to I.D.) is 700 kPa (100 psi) (equivalent to a 70 m depth of water-filled casing in a grouted borehole).

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PT GLOBAL TEKNIK PASUNDAN

SOLUSI TEKNIK

GEOKON PIEZOMETER

Category: Instrumentasi Geoteknik - Extensometer

globalteknikpasundan.com

SEMICONDUCTOR PIEZOMETERS AND PRESSURE TRANSDUCERS

GEOKON®

MODEL 3400

Model 3400S Semiconductor Piezometer

APPLICATIONS

For the measurement of:

- Ground water elevations
- Pore water pressure
- Pumping and slug tests
- Uplift pressures in dam foundations
- Hydraulic pressures in tanks and pipelines
- Wick drain efficiency
- Water pressure behind tunnel linings
- Aquifer storage and recovery
- Watershed, drainage basin and recharge areas
- Groundwater network automation

Model 3400SV Vented Semiconductor Piezometer.

OPERATING PRINCIPLE

The 3400 Series Semiconductor Piezometers (3400S/SV) and Pressure Transducers (3400H) are intended for dynamic measurements of fluid or pore water pressure, or for static pressure measurements where the readout system or data acquisition system is incompatible with vibrating wire type transducers.

The transducers use molecularly bonded (CVD) high output strain gauges to provide 100 mV output for full pressure when used with a 10 VDC supply. The high output versions are fitted with an ASIC providing outputs of 0–5 VDC or 4–20 mA, which are capable of being used in control and indicating loops without further amplification.

Piezometers incorporate a filter stone ahead of the diaphragm, which allows the fluid to pass through but prevents soil particles from impinging directly on the diaphragm. Standard porous filters are stainless steel. High air-entry ceramic filters are available for use in applications requiring that air be prevented from passing through the filter.

ADVANTAGES AND LIMITATIONS

The transducer is made from 17-4 stainless steel and is housed in a rugged stainless steel housing guaranteeing a high level of corrosion resistance, and providing long term reliable measurements in all applications.

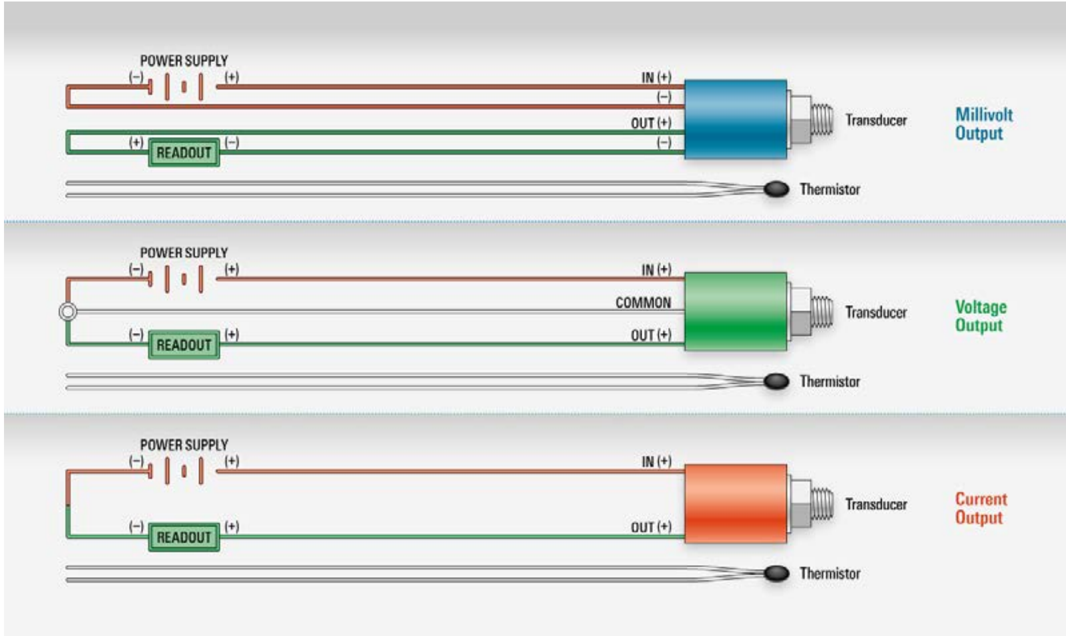
Signal cables are attached via proprietary bulkhead seals providing a high integrity, waterproof assembly. A variety of cable types are available to suit particular user applications.

Vented piezometers, designed to eliminate the effect of barometric pressure changes on water level measurements, are also available. The space inside the transducer is connected via a tube (integral within the cable) to the atmosphere. A chamber containing desiccant capsules is attached to the outer end of this tube to prevent moisture from entering the transducer cavity. A length of standard cable is spliced onto the end of the readout cable to allow for a standard connection.

Vented piezometers are better suited for water level monitoring applications, and typically not intended to be used to monitor pore pressures. Vented piezometers require more maintenance then unvented types, since moisture may find its way inside the transducer and ruin it.

A thermistor located in the housing permits the simultaneous measurement of temperature at the piezometer location.

Model 3400H and Dial Gauge Pressure Transducer on a tee fitting.



Model 3400 Series Semiconductor Piezometer wiring schematics.

TECHNICAL SPECIFICATIONS	
Standard Ranges	100, 250, 400, 600 kPa; 1, 2.5, 6 MPa
Over Range	2 × rated pressure
Response Time	0.5 ms
Wetted Parts	(Transducer) 17–4 PH stainless steel
Output	10 mV/v, 4–20 mA, 0–5 V
Accuracy	<0.1% F.S. (dependent on readout)
Linearity	<0.5% F.S.
Shock	20 g, 11 ms (per MIL-STD.-810E Method 516.4 Proc 1)
Temperature Range	–20 °C to +80 °C
Dimensions (L × Ø)	194 × 32 mm

INPUT/OUTPUT SPECIFICATIONS

Model	Output Type	Input	Output
3400H-1, 3400S-1, 3400SV-1	Millivolt	10 VDC regulated	100 mV (10 mV/V)
3400H-2, 3400S-2, 3400SV-2	Voltage	6.5–35 VDC	0–5 VDC
3400H-3, 3400S-3, 3400SV-3	Current	24 VDC (7–35 VDC)	4–20 mA (2 wire)

CABLE SPECIFICATIONS	
3400H-1, 3400S-1, 3400H-2, 3400S-2	**04-375V9:** 4 twisted pairs, Violet PVC Jacket, 9.53 mm Ø
3400SV-1, 3400SV-2	**04-375VT1:** 4 twisted pairs, Black PVC Jacket, integral vent tube, 9.5 mm Ø, transitions to: **04-375V9:** 4 twisted pairs, Violet PVC Jacket, 9.5 mm Ø
3400H-3, 3400S-3	**02-250V6:** 2 twisted pairs, Blue PVC Jacket, 6.35 mm Ø
3400SV-3	**02-335VT8:** 2 twisted pairs, Yellow Polyurethane Jacket, integral vent tube, 8.51 mm Ø, transitions to: **02-250V6:** 2 twisted pairs, Blue PVC Jacket, 6.35 mm Ø

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PIEZOMETERS AND PRESSURE TRANSDUCERS

GEOKON®

MODEL 4500 SERIES

Front to back Model 4500C, 4500S, 4500H, 4500DP and 4500HD Vibrating Wire Piezometers (front to back).

APPLICATIONS

For the measurement of:

- Ground water elevations
- Pore water pressures
- Pump tests
- Uplift pressures in dam foundations
- Hydraulic pressures in tanks and pipelines
- Wick drain efficiency
- Water pressures behind tunnel linings

OPERATING PRINCIPLE

The transducer uses a pressure sensitive diaphragm with a vibrating wire element attached to it. The diaphragm is welded to a capsule which is evacuated and hermetically sealed. Fluid pressures acting upon the outer face of the diaphragm cause deflections of the diaphragm and changes in tension and frequency of the vibrating wire. The changing frequency is sensed and transmitted to the readout device by an electrical coil acting through the walls of the capsule.

Piezometers incorporate a porous filter stone ahead of the diaphragm, which allows the fluid to pass through but prevents soil particles from impinging directly on the diaphragm.

ADVANTAGES & LIMITATIONS

The 4500 Series Vibrating Wire Piezometers and Pressure Transducers have outstanding long-term stability and reliability, and low thermal zero shift. Cable lengths of several kilometers are no problem and the frequency output signal is not affected by changing cable resistances (caused by splicing, changes of length, terminal contact resistances, etc.), nor by penetration of moisture into the electronic circuitry.

A thermistor, located in the housing, permits the measurement of temperature at the piezometer location.

All-stainless steel construction and evacuation of the capsule[1] guarantees a high level of corrosion resistance. Integral gas discharge tubes inside the main housing protect against lightning damage.

Standard porous filters are made from sintered stainless steel. High air-entry ceramic filters are also available.

Vented piezometers, designed to eliminate the effect of barometric pressure changes on water level measurements, are also available. The space inside the transducer is connected via a tube (integral within the cable) to the atmosphere. A chamber containing desiccant capsules is attached to the outer end of this tube to prevent moisture from entering the transducer cavity. A length of standard cable is spliced onto the end of the readout cable to allow for a standard connection.

Vented piezometers are better suited for water level monitoring applications, and typically not intended to be used to monitor pore pressures. Vented piezometers require more maintenance then unvented types, since moisture may find its way inside the transducer and ruin it.

For use in seawater and other chemically aggressive environments, corrosion resistant and high temperature 4500 models are also available. Refer to the 4500CR and 4500HT datasheets for more information.

Where measurements of rapidly changing pressures are required, the 4500 series piezometers and pressure transducers can be read using the CSI Dynamic VW Analyzer[2] (or similar). Alternatively, the 3400 series piezometers and pressure transducers (semiconductor type) could be considered.

[1]Evacuation does not apply to vented models.
[2]https://www.campbellsci.com/dynamic-vibrating-wire

TECHNICAL SPECIFICATIONS

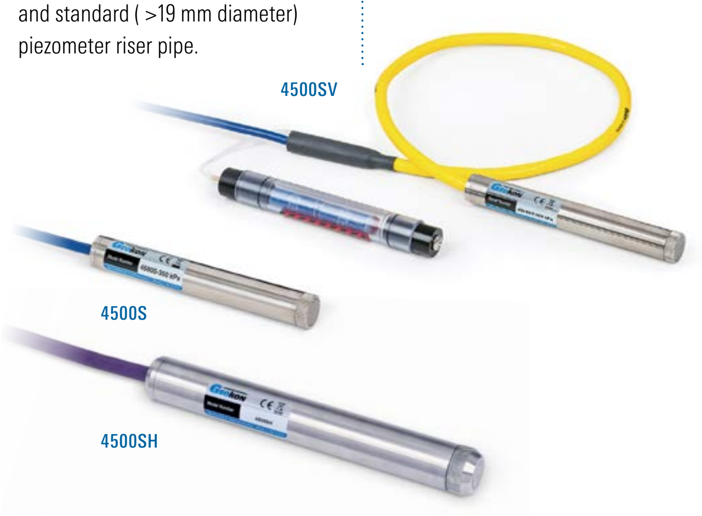
Model	Standard Ranges	Over Range	Resolution	Accuracy[1]	Linearity	Temperature Range[2]	Thermal Zero Shift	Diaphragm Displacement	Length × Diameter	Mass
4500S	350, 700 kPa; 1, 2, 3 MPa	1.5 × rated pressure	0.025% F.S.	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	–20 °C to +80 °C	< 0.05% F.S./°C	< 0.001 cm^3 at F.S.	133 × 19.1 mm	0.12 kg
4500SH	350, 700 kPa; 1, 2, 3, 5, 7.5, 10, 20 MPa	1.5 × rated pressure	0.025% F.S.	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	–20 °C to +80 °C	< 0.05% F.S./°C	< 0.001 cm^3 at F.S.	194 × 25.4 mm	0.44 kg
4500SV	350, 700 kPa	1.5 × rated pressure	0.025% F.S.	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	–20 °C to +80 °C	< 0.05% F.S./°C	< 0.001 cm^3 at F.S.	146 × 19.1 mm	0.20 kg
4500AL/ALV	70, 170 kPa	1.5 × rated pressure	0.025% F.S.	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	–20 °C to +80 °C	< 0.1% F.S./°C	< 0.001 cm^3 at F.S.	133 × 25.4 mm	0.25 kg
4500B	350, 700 kPa; 1, 2, 3 MPa	1.5 × rated pressure	0.025% F.S.	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	–20 °C to +80 °C	< 0.05% F.S./°C	< 0.001 cm^3 at F.S.	133 × 17.5 mm	0.10 kg
4500BV	350, 700 kPa; 2 MPa	1.5 × rated pressure	0.025% F.S.	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	–20 °C to +80 °C	< 0.05% F.S./°C	< 0.001 cm^3 at F.S.	133 × 17.5 mm	0.10 kg
4500C	350, 700 kPa	1.5 × rated pressure	0.05% F.S.	±0.1% F.S.	< 0.5% F.S.	–20 °C to +80 °C	< 0.05% F.S./°C	< 0.001 cm^3 at F.S.	165 × 11 mm	0.09 kg
4500DP	70, 170, 350, 700 kPa; 1, 2, 3 MPa	1.5 × rated pressure	0.025% F.S.	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	–20 °C to +80 °C	< 0.05% F.S./°C	< 0.001 cm^3 at F.S.	187 × 33.3 mm	0.90 kg
4500HD	70, 170, 350, 700 kPa; 1, 2, 3, 5, 7.5 MPa	1.5 × rated pressure	0.025% F.S.	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	–20 °C to +80 °C	< 0.05% F.S./°C	< 0.001 cm^3 at F.S.	203 × 38.1 mm	1.50 kg
4500H[3]	70, 170, 350, 700 kPa; 1, 2, 3 MPa	1.5 × rated pressure	0.025% F.S.	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	–20 °C to +80 °C	< 0.05% F.S./°C	< 0.001 cm^3 at F.S.	140 × 32 mm[4] 140 × 25.4 mm	0.30 kg
4500HH[3]	5, 7.5, 10, 20, 35, 75, 100 MPa	1.5 × rated pressure	0.025% F.S.	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	–20 °C to +80 °C	< 0.05% F.S./°C	< 0.001 cm^3 at F.S.	143 × 25.4 mm	0.30 kg
4580-1 (Barometer)	200 mbar[2]	1.5 × rated pressure	0.025% F.S.[5]	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	–20 °C to +80 °C	< 0.01% F.S./°C	n/a	110 × 63.5 mm	1.18 kg
4580-2	35 kPa	1.5 × rated pressure	0.025% F.S.[5]	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	–20 °C to +80 °C	< 0.01% F.S./°C	n/a	165 × 38 mm	0.86 kg
4580-2V	17, 35 kPa	1.5 × rated pressure	0.025% F.S.[5]	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	–20 °C to +80 °C	< 0.01% F.S./°C	n/a	165 × 38 mm	0.86 kg
4580-3V	7 kPa	1.5 × rated pressure	0.025% F.S.[5]	±0.1% F.S.	< 0.5% F.S. (±0.1% F.S. optional)	–20 °C to +80 °C	< 0.01% F.S./°C	n/a	165 × 63.5 mm	1.72 kg

Note: PSI = kPa × 0.14503, or MPa × 145.03. Piezometers with a range of 350 kPa and higher are capable of reading negative pressures to –100 kPa. Contact GEOKON for more information.
[1]Accuracy established under laboratory conditions.
[2]Other ranges available on request.
[3]All high pressure sensors are potentially dangerous and care must be taken not to over-range them beyond their calibrated range. Sensors are tested to 150% of the range to provide a factor of safety.
[4]For 70 and 170 kPa range only.
[5]Depends on readout system.

MODEL 4500S/SV/SH STANDARD PIEZOMETERS

The Model 4500S/SV Standard Piezometer is designed to measure fluid pressures such as ground water elevations and pore pressures when buried directly in embankments, fills, etc. It is also suitable for installation inside boreholes, observation wells and standard (>19 mm diameter) piezometer riser pipe.

The Model 4500SH is designed with a heavy duty housing. The vented version (Model 4500SV) provides automatic compensation for barometric pressure changes, via a cable with an integral vent tube.



MODEL 4500AL/ALV STANDARD PIEZOMETERS

The Model 4500AL is designed for low-pressure ranges. The vented version (Model 4500ALV) provides automatic compensation for barometric pressure changes, via a cable with an integral vent tube.

MODEL 4500B/BV/C SMALL DIAMETER PIEZOMETERS

These piezometers are designed to enable the automation of small diameter piezometer standpipes.

The 4500B and 4500BV are designed to fit inside 19 mm pipe and the 4500C fits inside a 12 mm pipe.

4500B 4500BV 4500C

MODEL 4500DP DRIVE POINT PIEZOMETERS

The standard Model 4500DP Drive Point Piezometer has the transducer located inside a housing with an EW drill rod thread and removable pointed nose cone. The unit can be pushed directly into soft ground with the signal cable located inside the drill rod. This model is ideally suited for use in soft clays and landfills. The piezometer may be recovered at the end of the job. The Model 4500DP is available with a variety of thread configurations allowing for installation using cone penetrometer or other drill rods with adapters.

4500DP 4500DPCT

MODEL 4500HD HEAVY DUTY PIEZOMETER

The Model 4500HD Heavy Duty Piezometer is designed for direct burial in fills and dam embankments. The 4500HD is used in conjunction with heavily armored cable to withstand earth movements during construction. Recommended for use in earth dams.

4500HD

MODEL 4500H/HH PRESSURE TRANSDUCERS

The Model 4500H and 4500HH Pressure Transducers are supplied with ¼-18 female NPT (4500H) and 7⁄16-20 60 degree female medium pressure (4500HH) fittings to permit the transducer to be coupled directly into hydraulic or pneumatic pressure lines. Other pipe thread sizes are also available.

4500H 4500HH

MODEL 4580-1 BAROMETER

The Model 4580-1 is a barometer used to measure atmospheric pressure changes. The barometric sensors are calibrated at the factory and referenced to an absolute barometric reading in millibars. Model 4580-1-ENCL is a protective fiberglass enclosure with integral vent.

4580-1

4580-1-ENCL

MODEL 4580-2/2V/3V PRESSURE TRANSDUCERS

The Model 4580 Pressure Transducers are designed for very low fluid pressure measurements, such as groundwater elevations in wells, water levels in streams, weirs, flumes, etc. Changes in water levels of as little as 0.2 mm can be measured

4580-2 4580-2V 4580-3V

ORDERING INFORMATION

CABLES

02-250V6-E/M: Blue PVC Cable, 6 mm (0.250") Ø, 2 twisted pairs.

03-250V0-E/M: Black Vinyl Cable, 6 mm (0.250") Ø, 3 twisted pairs.

02-250PILT-E/M: Violet Polyurethane Cable, 6 mm (0.25") Ø, 2 twisted pairs, low temperature (-40 to +80 °C), 50 ohm

02-313PI-E/M: Black Polyurethane Cable, with integral straining wire, 2 twisted pairs.

02-313V6-E/M: Blue PVC Cable, 8 mm (0.313") Ø, 2 twisted pairs with Kevlar reinforcement.

02-335VT8-E/M: Yellow Polyurethane Cable, with integral 3 mm (0.125") Ø polyethylene vent tube, 9 mm (0.335") Ø, 2 twisted pairs.

02-500PE1A-E/M: Black Polyethylene Cable, with served armor, 13 mm (0.500") Ø, 2 twisted pairs, overall braided shield.

FILTER STONES

4500-1A: Replacement stainless steel filter stone assembly for Model 4500AL Piezometer.

4500-1B: Replacement stainless steel filter stone assembly for Model 4500B Piezometer.

4500-1C: Replacement stainless steel filter stone assembly for Model 4500HD Piezometer.

4500-1S: Replacement stainless steel filter stone assembly for Model 4500S Piezometer.

4500-1SH: Replacement stainless steel filter stone assembly for Model 4500SH Piezometer.

4500-1-1: Replacement high air entry filter stone assembly for 4500S piezometers, 1 bar.

4500-1-2: Replacement high air entry filter stone assembly for 4500S piezometers, 2 bar.

4500-1-5: Replacement high air entry filter stone assembly for 4500S piezometers, 5 bar.

4500-2-1: Replacement high air entry filter stone assembly for 4500AL piezometers, 1 bar.

4500-2-2: Replacement high air entry filter stone assembly for 4500AL piezometers, 2 bar.

4500-2-5: Replacement high air entry filter stone assembly for 4500AL piezometers, 5 bar.

4500-2-6: Replacement high air entry filter stone assembly for 4500HD piezometers, 1 bar.

4500-2-7: Replacement high air entry filter stone assembly for 4500HD piezometers, 2 bar.

4500-2-8: Replacement high air entry filter stone assembly for 4500HD piezometers, 5 bar.

4500-3: Replacement stainless steel mesh type filter, mesh only, for 4500S/4500B piezometers.

4500-5: Factory sealed piezometer cap for shipping saturated piezometers with HAE filters, S size.

4500-5A: Factory sealed piezometer cap for shipping saturated piezometers with HAE filters, AL size.

4500-5B: Factory sealed piezometer cap for shipping saturated piezometers with HAE filters, HD size.

SPLICE KITS

4500-9-HD: Splice kit for armored cable, factory splice only.

4500-9-HDF1: Splice kit for armored cable, field use.

4500-9-HDF2: Splice kit for armored to unarmored cable, field use.

4500-9EP: Epoxy Resin and Hardener (138cc).

4500-9-SSI: Splice kit for settlement systems, for vented electrical cable and fluid filled tubes.

4500-10: Splice Kit for 6 mm (0.250") cable, complete with butt splices and epoxy.

4500-11: Splice Kit for 9 mm (0.335") vented cable, complete with butt splices, tube union and epoxy.

4500-12: Splice Kit for 10 mm (0.375") cable, complete with butt splices and epoxy.

4500-13: Splice Kit for 13 mm (0.500)" cable, complete with butt splices and epoxy.

4500-14: Splice Kit for 16 mm (0.625") cable, complete with butt splices and epoxy.

4500-15: Splice Kit for 5 mm (0.187") cable, complete with butt splices and epoxy.

4500-16: Splice Kit for 8 mm (0.312") cable (not SR), complete with butt splices and epoxy.

CONNECTORS

4500-20: 10-Pin Male Connector with Cap.

4500-20V: 10-Pin Male Pigtail with tinned leads.

4500-21: 10-Pin Female Connector with Cap

4500-21V: 10-Pin Female Pigtail with tinned leads.

ACCESSORIES

4500-6: Canvas bag.

4500-7: Moisture trap with desiccant capsules (2) for 3 mm (⅛") polyethylene tube vent line.

4500-8: Desiccant capsule for moisture traps.

4500-40-1: Magnetic Shield for 19 mm (3/4") Ø sensor.

4500-40-2: Magnetic Shield for 25 mm (1") Ø sensor.

4500-40-3: Magnetic Shield for 38 mm (1.5") Ø sensor.

4580-1-ENCL: Standard enclosure for Barometer. Includes mounting plate, clamp, and breather vent.

CON-A350: Kellems Grip for 6–8 mm (0.22–0.32") Ø Cable.

CON-A351: Kellems Grip for 7–9 mm (0.29–0.37") Ø Cable.

CORROSION RESISTANT PIEZOMETERS + PRESSURE TRANSDUCERS

GEOKON®

MODEL 4500CR SERIES

Model 4500INCO-170KPA with PVC cable (top) and Model 4500INCO-350KPA with PVC cable (bottom).

Model 4500TI-2MPA with 316 stainless steel encapsulated cable (top) and Model 4500TI-2MPA with PVC cable (bottom).

APPLICATIONS

Ideally suited for:

- Landfills
- Chemically aggressive mine tailings
- Heap Leach Pads
- Marine or highly saline conditions

For the measurement of:

- Ground water elevations
- Pore water pressures
- Contaminant plumes

OPERATING PRINCIPLE

The CR Series Vibrating Wire Piezometers and Pressure Transducers are designed for use in chemically aggressive environments, such as mine tailings, leach pads, and marine applications, where standard vibrating wire piezometers may not be particularly suitable, especially for long term monitoring. The transducer uses a pressure sensitive diaphragm with a vibrating wire element attached to it. The diaphragm is welded to a capsule which is evacuated and hermetically sealed. Fluid pressures acting upon the outer face of the diaphragm cause deflections of the diaphragm and changes in tension and frequency of the vibrating wire. The changing frequency is sensed and transmitted to the readout by an electrical coil acting through the walls of the capsule. Piezometers incorporate a porous filter stone ahead of the diaphragm, which allows fluid to pass through while preventing soil particles from impinging directly on the diaphragm.

ADVANTAGES AND LIMITATIONS

As with the 4500S and 4500AL Series[1], the 4500CR Series Vibrating Wire Piezometers and Pressure Transducers have outstanding long-term stability and reliability, and a low thermal sensitivity. The main advantage of the 4500CR Series over the 4500S/AL Series lies in the corrosion resistant materials used in their construction, which makes them particularly well suited for use in marine, landfill, or chemically aggressive environments.

For many applications, the 316 stainless steel used in the 4500S/AL Series may suffice. But where additional corrosion resistance is required, the 4500CR Series, with versions manufactured from Inconel® (4500INCO) or Titanium (4500TI), can be considered. Both models incorporate enhanced seals at the cable entry and filter connection. (Model 4500INCO utilizes a custom, dual O-ring seal, while the 4500TI employs an all-welded construction.) The porous filters used in the CR Series match the material of the respective Models; Inconel for the 4500INCO and Titanium for the 4500TI.

Lengthy cable runs are not a problem, as the frequency output is not affected by changing cable resistances (caused by splicing or contact resistances). A thermistor (or a vibrating wire temperature sensor) located in the transducer housing permits the measurement of temperatures at the piezometer location. Internal gas discharge tubes protect against lightning damage.

A variety of cable options are available to complement the 4500CR Series. In addition to the standard PVC and Polyurethane jacketed cables, conductors encased in annealed 316 stainless steel or Duplex 2205® stainless steel are also available.

[1] Refer to the 4500 Series data sheet for more information on Models 4500S and 4500AL.

CHEMICAL RESISTANCE

The choice of piezometer and cable is largely dependent on the chemical composition of the water in the area of study and the materials through which the cables are to be routed. Often times, the appropriate selection can be made by assessing the performance of materials in equipment such as pumps, pipes and valves etc. already existing at the project site. Beyond this a number of Chemical Resistance Guides are available on the Internet to aid in selection[2]; but it is important to keep in mind that the chemical resistance of the metals and cables used in the piezometer construction can be affected not only by chemical concentration, but also by chemical combinations and temperatures.

[2] Contact Geokon for help finding references.

TECHNICAL SPECIFICATIONS

Model	Standard Ranges[1]	Over Range	Resolution	Accuracy[2]	Linearity	Nominal Temperature Range[1 3]	Thermal Zero Shift	Diaphragm Displacement	Length × Diameter, Mass
4500INCO	70, 170 kPa	1.5 × rated pressure	0.025% F.S.	±0.1% F.S.	< 0.5% F.S.	−20 °C to +80 °C	< 0.1% F.S./°C (70 and 170 kPa) < 0.05% F.S./°C (All others)	< 0.001 cm^3 at F.S.	133 × 25.4 mm, 0.25 kg (70 and 170 kPa)
	350, 700 kPa								133 × 19.1 mm, 0.12 kg (350 kPa to 5 MPa)
	1, 2, 3, 5 MPa 7.5, 10, 20 MPa								194 × 25.4 mm, 0.44 kg (7.5 to 20 MPa)
4500TI	350, 700 kPa	1.5 × rated pressure	0.025% F.S.	±0.1% F.S.	< 0.5% F.S.	−20 °C to +80 °C	< 0.1% F.S./°C	< 0.001 cm^3 at F.S.	125 × 25.4 mm, 0.19 kg (350 kPa to 3 MPa)
	1, 2, 3, 5, 7.5, 10 MPa								168 x 25.4 mm, 0.28 kg (5 to 10 MPa)

Notes: PSI = kPa × 0.14503, or MPa × 145.03. Piezometers with a range of 350 kPa and higher are capable of reading negative pressures to −100 kPa. Contact GEOKON for more information.

[1]Other ranges available on request.
[2]Accuracy established under laboratory conditions.

[3]–40C to +80°C with corresponding cable as shown below in Cable Specifications.

CABLE SPECIFICATIONS

Model	Conductors	Conductor Insulation	Drain Wire	Jacket	Nominal OD	Temperature Range
02-250V6-E/M	4-conductors, 2 twisted pair, 22 AWG 7/30	8 mil HDPP	24 AWG	PVC (Blue)	6.35 mm (±0.25 mm) [0.25"]	−20 to +80 °C
02-250P4-E/M	4-conductors, 2 twisted pair, 22 AWG 7/30	8 mil HDPP	24 AWG	Polyurethane (Green)	6.35 mm (±0.25 mm) [0.25"]	−20 to +80 °C
02-250P9LT-E/M	4-conductors, 2 twisted pair, 22 AWG 7/30	8 mil HDPP	24 AWG	Polyurethane (Violet)	6.35 mm (±0.25 mm) [0.25"]	−40 to +80 °C
02-312PS4-E/M	4-conductors, 2 twisted pair, 22 AWG 7/30	10 mil HDPP	24 AWG	Polyurethane (Green) w/Braided Sheild	7.95 mm (±0.38 mm) [0.313"]	−20 to +80 °C
02-313PI-E/M	4-conductors, 2 twisted pair, 22 AWG 7/30	10 mil HDPP	24 AWG	Polyurethane (Black) w/Intregral SS Straining Wire	7.95 mm (±0.38 mm) [0.313"]	−20 to +80 °C
02-313V6-E/M	4-conductors, 2 twisted pair, 22 AWG 7/30	10 mil HDPP	24 AWG	PVC (Blue) w/Kevlar Strain Relief	7.95 mm (±0.38 mm) [0.313"]	−20 to +80 °C
02-250PEP-E/M-316	4-conductors, 24 AWG Solid	8 mil PTFE	N/A	316ss, 1mm (0.035") wall ±15% Collapse Pressure: 6,540 psi Tensile Strength: 2,010 lbs Yield Strength: 945 lbs Elongation: 300%	6.35 mm (±0.13 mm) [0.25"]	−150 to +300 °C
02-250PEP-E/M-2205	4-conductors, 24 AWG Solid	8 mil PTFE	N/A	Duplex 2205, 1mm (0.035") wall ±15% Collapse Pressure: 17,400 psi Tensile Strength: 2,245 lbs Yield Strength: 1,655 lbs Elongation: 300%	6.35 mm (±0.13 mm) [0.25"]	−150 to +300 °C

ORDERING INFORMATION

4500INCO-70KPA: Vibrating Wire Piezometer, Inconel wetted parts, 70 kPa
4500INCO-170KPA: Vibrating Wire Piezometer, Inconel wetted parts, 170 kPa
4500INCO-350KPA: Vibrating Wire Piezometer, Inconel wetted parts, 350 kPa
4500INCO-700KPA: Vibrating Wire Piezometer, Inconel wetted parts, 700 kPa
4500INCO-1MPA: Vibrating Wire Piezometer, Inconel wetted parts, 1 MPa
4500INCO-2MPA: Vibrating Wire Piezometer, Inconel wetted parts, 2 MPa
4500INCO-3MPA: Vibrating Wire Piezometer, Inconel wetted parts, 3 MPa
4500INCO-5MPA: Vibrating Wire Piezometer, Inconel wetted parts, 5 MPa
4500INCO-7.5MPA: Vibrating Wire Piezometer, Inconel wetted parts, 7.5 MPa
4500INCO-10MPA: Vibrating Wire Piezometer, Inconel wetted parts, 10 MPa
4500INCO-20MPA: Vibrating Wire Piezometer, Inconel wetted parts, 20 MPa
4500TI-350KPA: Vibrating Wire Piezometer, all titanium construction, 350 kPa
4500TI-700KPA: Vibrating Wire Piezometer, all titanium construction, 700 kPa
4500TI-1MPA: Vibrating Wire Piezometer, all titanium construction, 1 MPa
4500TI-2MPA: Vibrating Wire Piezometer, all titanium construction, 2 MPa
4500TI-3MPA: Vibrating Wire Piezometer, all titanium construction, 3 MPa
4500TI-5MPA: Vibrating Wire Piezometer, all titanium construction, 5 MPa
4500TI-7.5MPA: Vibrating Wire Piezometer, all titanium construction, 7.5 MPa
4500TI-10MPA: Vibrating Wire Piezometer, all titanium construction, 10 MPa

02-250V6: Blue PVC Cable, 6.35 mm (±0.25 mm) [0.25"] Ø, 2 twisted pairs, for the above
02-250P4: Green Polyurethane Cable, 6.35 mm (±0.25 mm) [0.25"] Ø, 2 twisted pairs, for the above
02-250P9LT: Violet Polyurethane Cable, 6 mm (±0.25 mm) [0.25"] Ø, 2 twisted pairs, for the above
02-250PEP-316: 316 Stainless Steel Encapsulated Cable, 6.35 mm (±0.13 mm) [0.25"] Ø, 4 solid conductors, for the above
02-250PEP-2205: Duplex 2205 Stainless Steel Encapsulated Cable, 6.35 mm (±0.13 mm) [0.25"] Ø, 4 solid conductors, for the above

COMPATIBLE READOUTS AND DATALOGGERS

GK-404: Handheld Readout
GK-406: Vibrating Wire Analyzer
8600 Series: Multi-Channel Dataloggers
8800 and 8900 Series: GeoNet Wireless Data Acquisition System
8920 and 8930 Series: GeoNet Cellular and Wi-Fi Network Loggers
8940 Series: GeoNet Dataloggers

HIGH TEMPERATURE PIEZOMETERS AND PRESSURE TRANSDUCERS

GEOKON®

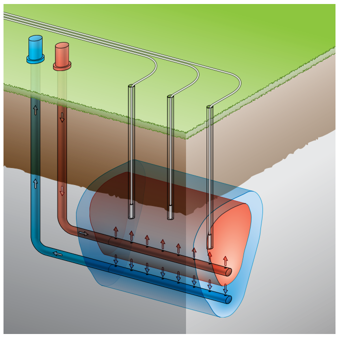
MODEL 4500HT SERIES

Model 4500HT High Temperature Piezometer (front) and Model 4500HHT High Temperature Pressure Transducers (center, back).

APPLICATIONS

For the measurement of downhole pressures and temperatures in:

- Oil recovery systems
- Geothermal applications



Model 4500HT used for monitoring pressures and temperatures in oil recovery applications.

INTRODUCTION

The 4500HT Series High Temperature Piezometers and 4500HHT Pressure Transducers are designed for monitoring downhole pressures and temperatures in oil recovery systems and geothermal applications.

These sensors are capable of operation under extreme conditions and at temperatures up to 250 °C. In thermal recovery applications (steam assisted gravity drainage (SAGD) or cyclic steam stimulation (CSS), they can provide accurate, real-time, continuous monitoring of pressures in production and injection wells thereby optimizing the recovery rate and reducing the costs of the steam injection process. In geothermal applications, they offer a means for in situ and continuous monitoring of pressures and temperatures over extended periods of time.

OPERATING PRINCIPLE

The sensors use a pressure sensitive diaphragm with a vibrating wire element attached to it. The diaphragm is welded to a capsule, which is evacuated and hermetically sealed. Fluid pressures acting upon the outer face of the diaphragm cause deflections of the diaphragm and changes in tension and frequency of the vibrating wire. The changing frequency is sensed and transmitted to the readout device by an electrical coil acting through the walls of the capsule.

Model 4500HT shown with TEC cable (coiled, pre-installed configuration).

ADVANTAGES AND LIMITATIONS

Vibrating wire sensors can be modified for use in environments subject to temperature extremes more easily than many other commercially available sensor types because the electromagnetic coil (used to excite the wire) is the only electronic component inside the sensor. In addition, the construction of vibrating wire sensors that are highly corrosion-resistant and capable of long-term use, in very aggressive environments, is possible due to the careful selection of materials and use of proprietary assembly techniques. All exposed components are made of corrosion-resistant stainless steels and internal components (plucking coils, electrical hook-up wire, thermistors, and internal seals) are high-temperature versions.

The 4500HT Series High Temperature Piezometers and 4500HHT Series Pressure Transducers offer outstanding long-term stability and reliability, and low thermal zero shift. Cable lengths of several kilometers are possible and the frequency output signal is not affected by changing cable resistances (caused by splicing, changes of length, terminal contact resistances, etc.), nor by penetration of moisture into the electronic circuitry. A secondary vibrating wire temperature sensor (or thermistor), located in the same housing, permits the measurement of temperatures at the piezometer location.

Calibrations are performed at six different temperatures throughout the range to determine zero shift and the change in gauge factor with temperature.

The 4500HT/HHT Series piezometers and pressure transducers are delivered either with mineral insulated cables, comprising 4 x 22 AWG solid copper conductors in magnesium oxide inside a stainless steel tube, or with tubular encapsulated cables (TEC) comprising 4 x 24 AWG stranded, tinned copper, conductors with PFA insulation, encapsulated inside a 316L stainless steel tube.

These sensors are designed for static measurements only and at least one second is required to excite and read the sensor.

TECHNICAL SPECIFICATIONS

Standard Ranges	350, 700 kPa; 1, 2, 3, 5, 7.5, 10, 20, 35, 50, 75, 100 MPa
Over Range	1.5 × rated pressure
Resolution	0.025% F.S. (minimum)
Accuracy[2]	±0.1% F.S.
Linearity	< 0.5% F.S. (±0.1% F.S. optional)
Temperature Range[1]	0 °C to +250 °C
Thermal Zero Shift	< 0.05% F.S./°C
Diaphragm Displacement	< 0.001 cm^3 at F.S
4500HT Piezometer Dimensions (L × Ø)[3]	191 × 19 mm (350, 700 kPa; 1, 2, 3, 5, 7.5, 10 MPa)
4500HHT Pressure Transducer Dimensions (L × Ø)[4]	191 × 19 mm (350, 700 kPa; 1, 2, 3, 5, 7.5, 10 MPa) 191 × 25 mm (20, 35 MPa) 216 × 32 mm (50, 75, 100 MPa)

Note: PSI = kPa × 0.14503, or MPa × 145.03.
[1]Piezometers with a range of 350 kPa and higher are capable of reading negative pressures to −100 kPa. Contact GEOKON for more information. Other ranges available on request.
[2]Accuracy established under laboratory conditions.
[3]Please contact GEOKON for dimensions of ranges higher than 10 MPa.
[4]Pressure Connections are Female 7⁄16-20 UNF Medium Pressure 60° Cone.

CABLE SPECIFICATIONS

Mineral Insulated		Tubular Encapsulated (TEC)	
Conductors	4-conductors, 22 AWG, solid copper	Conductors	4-conductors 24 AWG, stranded, tinned, copper
Sheath	Stainless Steel	Insulation	PFA
Sheath Wall	0.76 mm (0.03")	Sheath	316L Stainless Steel
Nominal O.D.	4.76 mm (0.1875")	Sheath wall	0.76 mm (0.03")
Coil ID	1 m (3 ft)	Nominal OD	4 mm (0.16")
		Coil Diameter	1 m (3 ft)

GEOKON
48 Spencer Street
Lebanon, NH 03766 • USA

www.geokon.com
e: info@geokon.com
p: +1 · 603 · 448 · 1562

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MULTILEVEL PIEZOMETERS

GEOKON®

MODEL 4500MLP

Model 4500MLP Multilevel Piezometer shown in open position.

APPLICATIONS

For the measurement of ground water pressures at multiple levels in a single borehole.

Model 4500MLP shown in closed, pre-installed configuration.

OPERATING PRINCIPLE

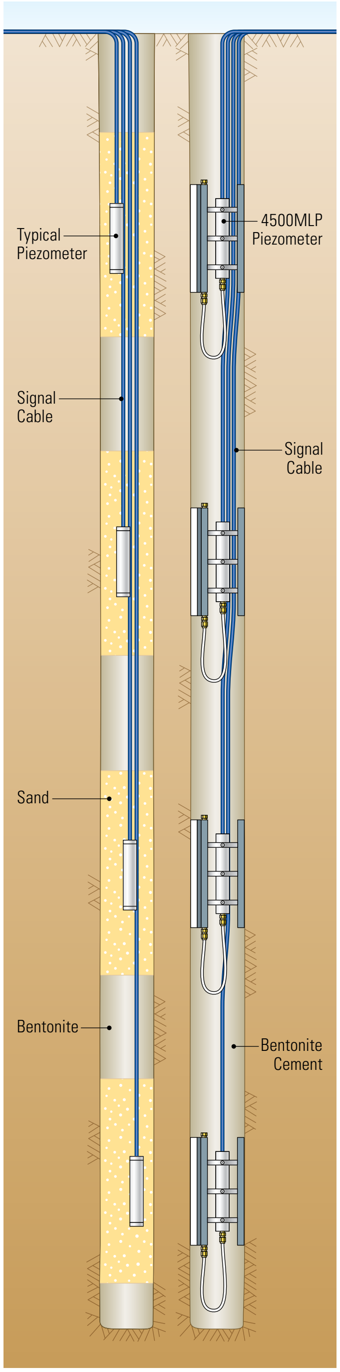
Where it is desirable to measure piezometric water pressures at more than one elevation in a single borehole there are difficulties in making multiple piezometer installations on account of the great amount of time and labor required to position the piezometers correctly, to surround them with sand lenses and to fill the intervening spaces with impermeable bentonite grout.

Much of the difficulty can be removed by eliminating the need for the sand lenses, replacing them with another method of ensuring that the piezometer tips are coupled hydraulically to the surrounding ground at each specific elevation. With the Multilevel Piezometer method, this is accomplished by a spring actuated device which presses the piezometer filter against the wall of the borehole so that it cannot be plugged by the bentonite. It thus becomes a simple operation, beginning with the lowest piezometer, to lower each piezometer by its cable to the desired elevation and then to actuate the spring loading mechanism which forces the filter against the wall of the borehole and holds the piezometer in place. When all the piezometers are in position, the borehole is filled with a bentonite cement slurry, from bottom to top, using a tremie pipe.

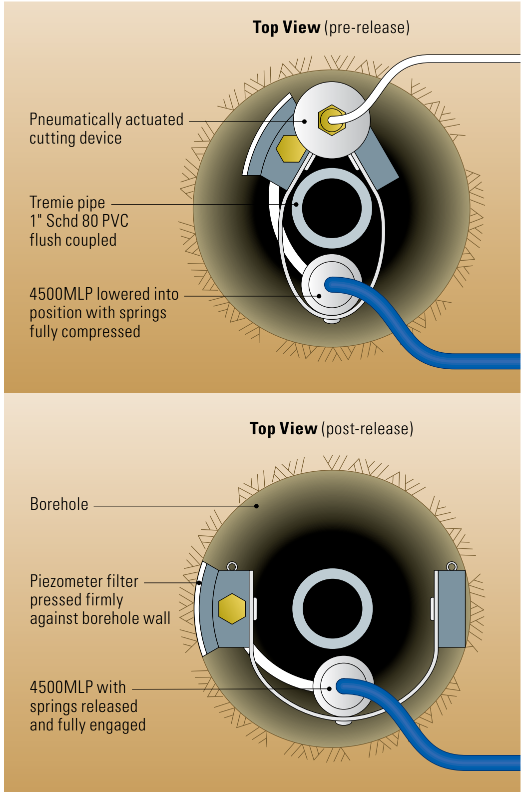
ADVANTAGES AND LIMITATIONS

The biggest advantage lies in the greatly reduced amount of time required for installation. Borehole sizes are not critical but they should be at least 100 mm in diameter and not more than 30 mm larger than the nominal size for which the spring loading mechanisms are designed.

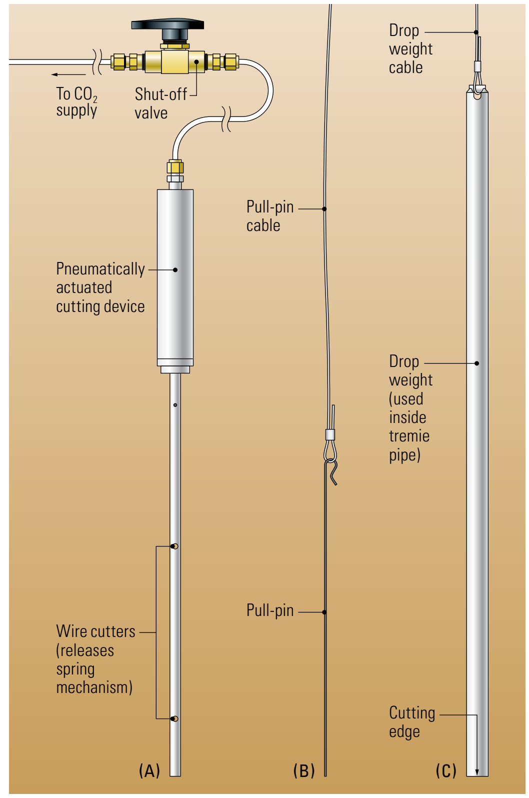
Care needs to be exercised in choosing the piezometer pressure range. During installation the full bentonite grout pressure will be felt by the piezometer for as long as it takes for the grout to set up and for the excess grout pressures to be dissipated. GEOKON vibrating wire piezometers can withstand over-ranging to 150% of the calibrated range without damage and without affecting the calibration. However, the piezometer may temporarily cease reading during the over-ranging and if the grout pressures are to be measured then the maximum pressure range of the piezometer should be selected accordingly.



Typical method of piezometer installation at multiple levels within a borehole (left) and the Multilevel Piezometer method, which allows a much faster, simpler installation (right).



Model 4500MLP installation details showing spring-loaded mechanism in closed configuration (top), then released (bottom).



Tie wrap release options: (A) pneumatically actuated cutting device; (B) pull-pin; (C) drop weight.

SYSTEM COMPONENTS

A grout tremie pipe that reaches the bottom of the borehole is required. The tremie pipe can be made from 1" PVC flush coupled pipe or equivalent.

The individual piezometer assemblies are lowered to their correct locations on the end of their signal cables, with the spring-loaded mechanism held in a closed configuration by tie wraps or by a pull-pin. The release of the spring-loaded mechanism is accomplished using 1 of 3 options: (A) a pneumatically actuated cutting device connected to a source of CO2 (supplied by the customer); (B) a pull-pin attached to a cable that leads to the surface (this option is not recommended for holes longer than 30 m); or (C) a drop weight—this option is used in vertical holes when the 4500MLPs are tie wrapped to the tremie pipe at predetermined depths. The tie wraps pass through the center of the tremie pipe and a cutting edge on the drop weight cuts the tie wrap as it falls inside the tremie pipe.

A supply of bentonite cement grout and a grout pump, with adapters to connect to the grout tremie pipe, is also required.

TECHNICAL SPECIFICATIONS

Standard Ranges[1]	70, 170, 350, 700 kPa; 1, 2, 3, 5, 7.5 MPa
Over Range[2]	1.5 × rated pressure
Resolution	0.025% F.S. (minimum)
Accuracy[3]	±0.1% F.S.
Linearity	< 0.5% F.S. (±0.1% F.S. optional)
Temperature Range[4]	−20 °C to +80 °C
Borehole Diameter	100–150 mm
Borehole Oversize Capacity	nominal size +30 mm
Cable	(non-vented) 02-250V6 4-conductor PVC jacket, 6.4 mm diameter (vented) 02-335VT8 4-conductor Polyurethane jacket, 9.5 mm diameter
Filter	Porous Polyethylene, 60 micron
Thermistor Operating Accuracy	±0.5° C

[1] Piezometers with a range of 350 kPa and higher are capable of reading negative pressures to −100 kPa. Please contact GEOKON for more information.
[2] Maximum, without damage.
[3] Accuracy established under laboratory conditions.
[4] Other ranges available on request.

GEOKON
48 Spencer Street
Lebanon, NH 03766 · USA

www.geokon.com
e: info@geokon.com
p: +1 · 603 · 448 · 1562

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CASAGRANDE STANDPIPE PIEZOMETER

GEOKON®

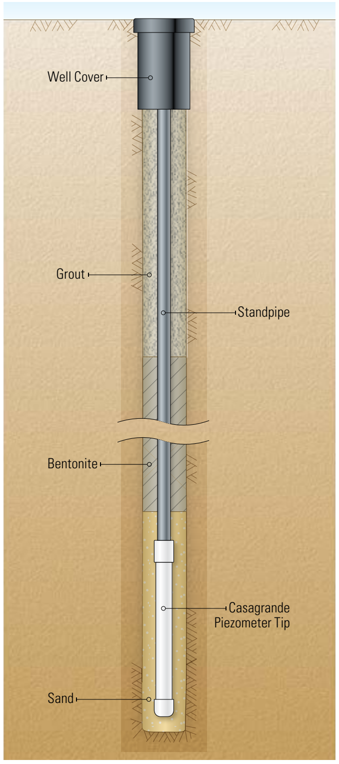
MODEL 4590

Model 4590 Casagrande Piezometer.

APPLICATIONS

For the measurement of…

- Ground water pressures
- Pore water pressures
- Slope stability studies
- Effectiveness of de-watering operations
- Wick drain efficiency



Casagrande standpipe piezometer schematic.

OPERATING PRINCIPLE

The 4590 Casagrande Piezometer is intended for measurements of pore pressures, groundwater sampling and monitoring in a simple and economic way and where time lags and or obstruction to construction are not critical.

The piezometer consists of a porous tip, attached to a riser pipe. The porous tip is isolated in the zone of interest, usually with an overlying bentonite seal. Water is free to flow through the porous tip and stabilizes in the riser pipe at the piezometric elevation.

The elevation of the water level in the riser is measured using a sounder or, more commonly and accurately, with a water level meter (such as the Solinst Model 101 —see separate data sheet)

ADVANTAGES & LIMITATIONS

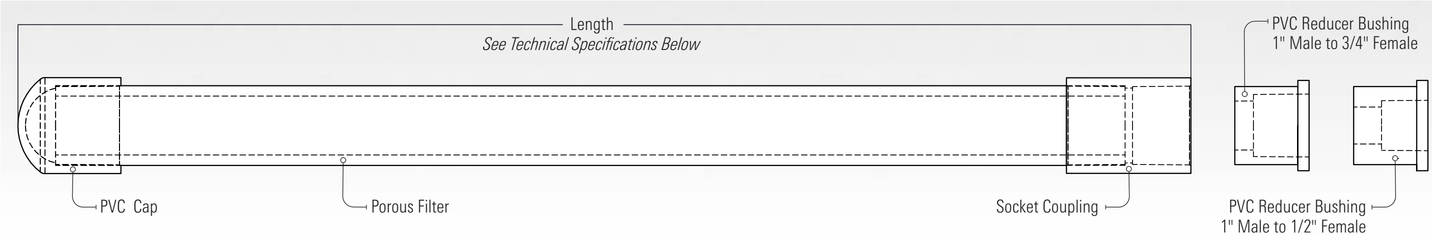
Open standpipe piezometers are quite reliable, with a long and successful performance record. They can also be used for groundwater sampling and to measure the permeability of the surrounding soil using constant, or falling head test methods.

One drawback of the standpipe piezometer is it's hydrodynamic time lag, which is much greater than that of diaphragm type piezometers because a much greater movement of pore or joint water is involved.

Standpipe piezometers are also more subject to damage by construction plant, than are buried types, and extending riser pipes through embankment fills can result in inferior compaction at the piezometer location.

Care should be taken to prevent rainwater run-off from entering open standpipes; stopcocks or well covers are available for this purpose.

In critical monitoring situations, and or where automatic readings are required at frequent intervals the standpipe piezometer is easily "converted" by installing a diaphragm type piezometer (Model 4500C for example).



Casagrande standpipe piezometer

Solinst Model 101 Water Level Meter.

Typical well cover.
(Photo provided courtesy of Martin Products, Inc. www.martinproducts.net)

OPTIONAL EQUIPMENT

PVC Riser Pipe:
Specify: 0.5", 0.75" or 1" and flush coupled or socket couplings.

Well Covers:
Specify: Size (7" standard).

Water Level Meters:
Specify: Tape length (please see the Solinst Model 101 data sheet)

TECHNICAL SPECIFICATIONS

The Casagrande Piezometer tip consists of a 50 micron porous plastic filter element with PVC fittings.

The unique design of the piezometer tip allows for connection to 0.5" (1.27 cm), 0.75" (1.91 cm) or 1" (2.54 cm) riser pipes.

Material	UHMW Polyethylene Tube, PVC Fittings
Available Connections	1" (2.54 cm), ¾" (1.91 cm), ½" (1.27 cm) nominal pipe size
Lengths	4590-11-12 | 13.74" (34.9 cm) 4590-11-18 | 19.74" (50.14 cm) 4590-11-24 | 25.74" (65.38 cm)
Maximum OD	1.64" (41.5 mm) on PVC fittings
Filter Dimensions	1.35" OD, 0.99" ID, 0.18" wall thickness
Effective Filter Area	4590-11-12 | 30.8 in^2 (198.71 cm^2) 4590-11-18 | 49.5 in^2 (319.35 cm^2) 4590-11-24 | 68.1 in^2 (439.35 cm^2)
Pore Diameter	50 micron
Hydraulic Conductivity	2.69×10^{-2} cm/s

**Photo provided courtesy of Martin Products, Inc. www.martinproducts.net*

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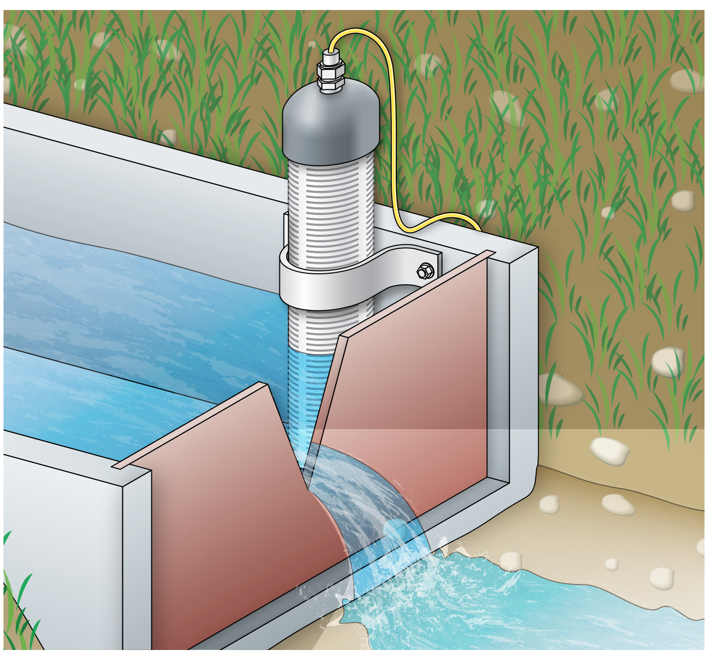
VIBRATING WIRE WEIR MONITOR

GEOKON®

MODEL 4675LV

The Model 4675LV with cutaway revealing its internal components: a cylindrical weight suspended from the vibrating wire force transducer.



Typical Model 4675LV installation.

APPLICATIONS

The Model 4675LV is used for the precision water level measurement and monitoring of:

- Weirs
- Tanks
- Stream levels
- Reservoir levels

OPERATING PRINCIPLE

The Model 4675LV is a precision water level monitoring system that uses a vibrating wire force transducer to provide a highly stable and sensitive means of monitoring water levels.

The main component is a cylindrical weight suspended from the vibrating wire force transducer. The cylinder hangs partially in the water whose level is to be monitored. As the water level changes, the changing buoyancy force on the cylinder acts directly on the vibrating wire transducer altering its tension and hence its resonant frequency.

In operation the vessel containing the Weir Monitor is connected hydraulically to the water whose level is to be measured. The vessel is positioned so that the bottom of the hanging cylinder is slightly below the bottom of the V-notch or flume.

ADVANTAGES AND LIMITATIONS

The main advantage of the 4675LV system lies in it's high sensitivity and stability, which allows water level changes of as little as 0.1 mm to be measured accurately.

The force transducer is immune to zero drift and has a very low response to temperature changes.

As with all vibrating wire sensors, because the output is a frequency, it is not affected by changes of cable resistance and hence long signal cables are not a problem.

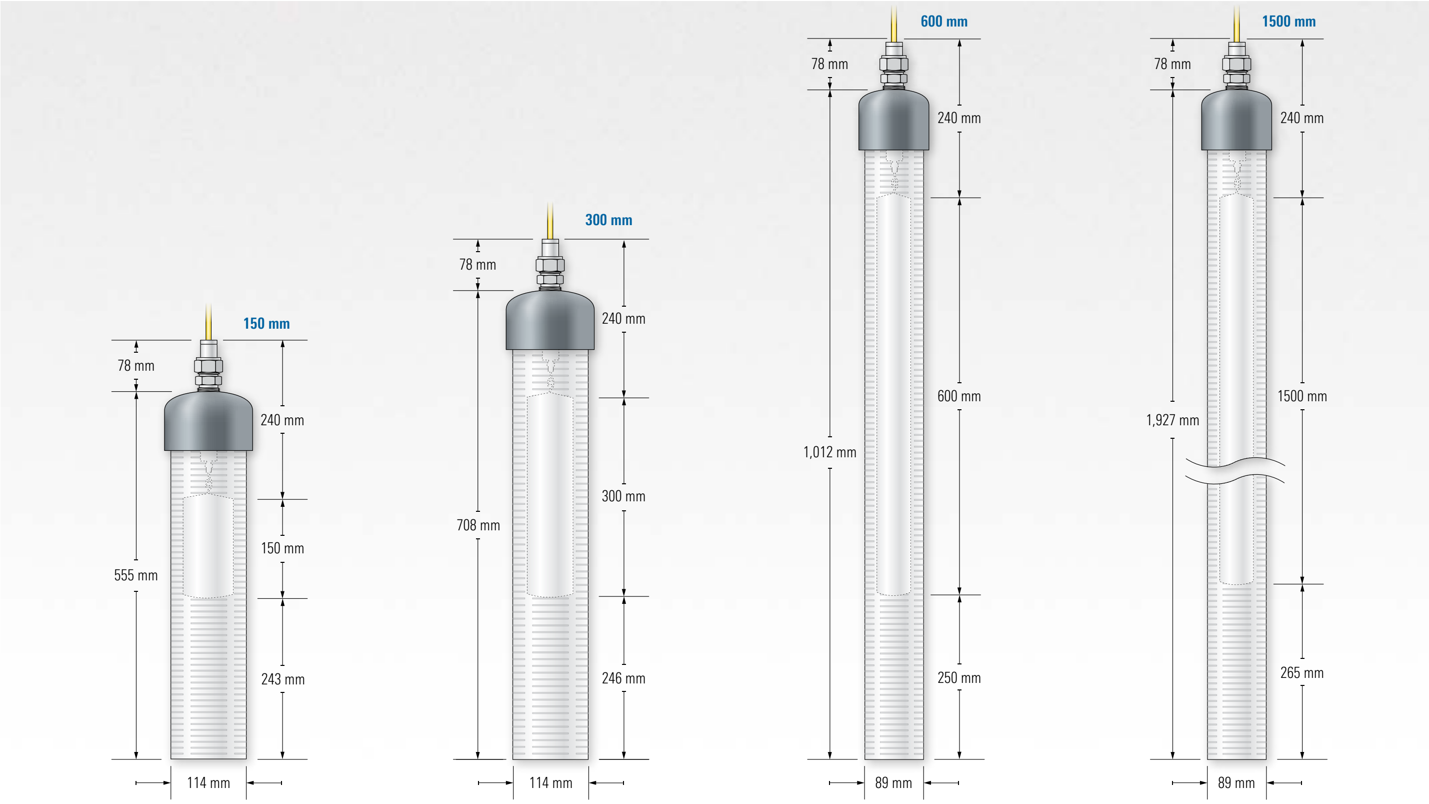
The frequency is measured by either a portable readout or datalogger.

4 to 20 mA or 0 to 5 V outputs can be obtained using the Model 8020-59 VW Frequency to Analog Converter.

SYSTEM COMPONENTS

The cylinder and force transducer are contained within a housing made from slotted PVC pipe. This pipe can be positioned within the weir or tank or it can be installed in a Stilling Well connected hydraulically to the tank or weir. The vibrating wire transducer is vented to the atmosphere so that barometric fluctuations are compensated for automatically.

The vent line terminates in a moisture trap which requires periodic maintenance to replace the desiccant. A length of GEOKON standard cable is spliced at onto the end of the readout cable to allow a standard connection to the chosen readout or datalogger.



Nominal lengths and diameters of the Model 4675LV standard ranges.

ORDERING INFORMATION

4675LV-1-150MM: Vibrating Wire Weir Monitoring System, 150 mm range, includes transducer, hanging weight, stilling well, desiccant chamber with capsules, and mounting hardware.
4675LV-1-300MM: Vibrating Wire Weir Monitoring System, 300 mm range, includes transducer, hanging weight, stilling well, desiccant chamber with capsules, and mounting hardware.
4675LV-1-600MM: Vibrating Wire Weir Monitoring System, 600 mm range, includes transducer, hanging weight, stilling well, desiccant chamber with capsules, and mounting hardware.
4675LV-1-1500MM: Vibrating Wire Weir Monitoring System, 1500 mm range, includes transducer, hanging weight, stilling well, desiccant chamber with capsules, and mounting hardware.
4675LV-2: Vibrating Wire Weir Monitoring System, transducer only, with desiccant chamber and capsules.
02-335VT8: Yellow Polyurethane Cable for the above, 8.50 mm (±0.38 mm) [0.335"] Ø, 2 twisted pairs, with integral 3.18 mm [0.125"] polyethylene vent tube.
TLS-208: Setting tool for 1/4" Rawl drop-in anchors. One required per installation.
4675LV-2-12: Stilling Well (Specify range).
4675LV-3-1: Stainless steel “V” notch weir plate, 22.5°, 30 cm, 14 L/sec.
4675LV-3-2: Stainless steel “V” notch weir plate, 45°, 30 cm, 28 L/sec.
4675LV-3-3: Stainless steel “V” notch weir plate, 60°, 30 cm, 39 L/sec.
4675LV-3-4: Stainless steel “V” notch weir plate, 90°, 30 cm, 68 L/sec.

COMPATIBLE READOUTS AND DATALOGGERS

GK-404: Handheld Readout
GK-406: Vibrating Wire Analyzer
8600 Series: Multi-Channel Dataloggers
8800 and 8900 Series: GeoNet Wireless Data Acquisition System
8920, 8930, and 8950 Series: GeoNet Cellular and Wi-Fi Network Loggers
8940 Series: GeoNet Dataloggers

TECHNICAL SPECIFICATIONS

Standard Ranges[1]	150, 300, 600, 1500 mm
Resolution	0.025% F.S. (minimum)
Accuracy[2]	±0.1% F.S.
Linearity	0.25% to 0.75%F.S.
Stability	±0.05% F.S. per year
Temperature Range[3]	−20 °C to +80 °C
Dimensions (L × Ø)	165 × 25 mm (transducer)

[1] Other ranges available on request.
[2] Accuracy established under laboratory conditions.
[3] Using anti-freeze solution can extend the range below 0 °C.

GEOKON
48 Spencer Street
Lebanon, NH 03766 · USA

www.geokon.com
e: info@geokon.com
p: +1 · 603 · 448 · 1562

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