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Instruction Manual

Model 1100

Borehole Extensometer

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1 THEORY OF OPERATION

1.1 Introduction

Borehole extensometers are used for monitoring displacements along the axis of the instrument in various applications (tunnels, shoring sidewalls, earthen dams, landslides, etc.) A series of borehole anchors interconnected by fiberglass, composite/graphite, or stainless steel connecting rods are installed at predetermined depths, with the deepest anchor installed in stable ground to serve as a nonmoving reference point. If a stable point cannot be established with the deepest anchor, the head of the extensometer can serve as the reference point but must be tied into an external survey system.

Each borehole anchor is typically coupled to a Vibrating Wire (VW) Displacement Transducer to measure the movement in each zone relative to the head. Anchor movements are sensed electronically with transducers or mechanically determined with a dial gauge where applicable, and a measurement of the position of the top of connecting rod relative to the anchor is determined. This not only enables the measurement of the magnitude of any movements but also narrows down the identification of zones of movements.

To ease installation, the extensometer should be assembled on the ground next to the borehole and then suspended and lowered into the borehole. The anchors are then set in place, either by applying hydraulic pressure (borros and bladder type anchors) or using cement grout (groutable anchors).

1.2 System Components

The four basic components of the extensometer are: the head assembly, Vibrating Wire Displacement Transducers (contained within the head assembly), connecting rods and tubing, and the borehole anchors. Each of these components are described in the sections that follow.

1.2.1 Head Assembly

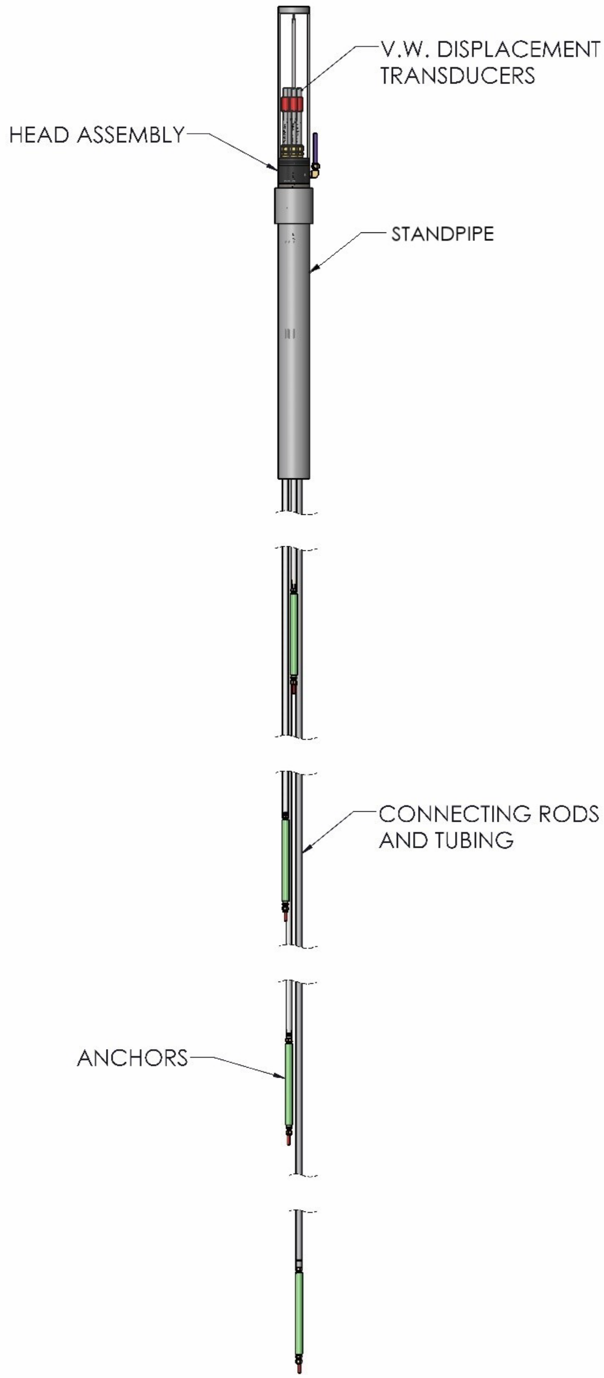

Figure 1 - Four Main Components of the Extensometer

The extensometer head assembly houses and protects the VW displacement transducers. The head assembly includes the following components:

- Protective cap
- Side-exit cable (custom top exit available)
- PVC coupling (or flange)
- PVC standpipe.

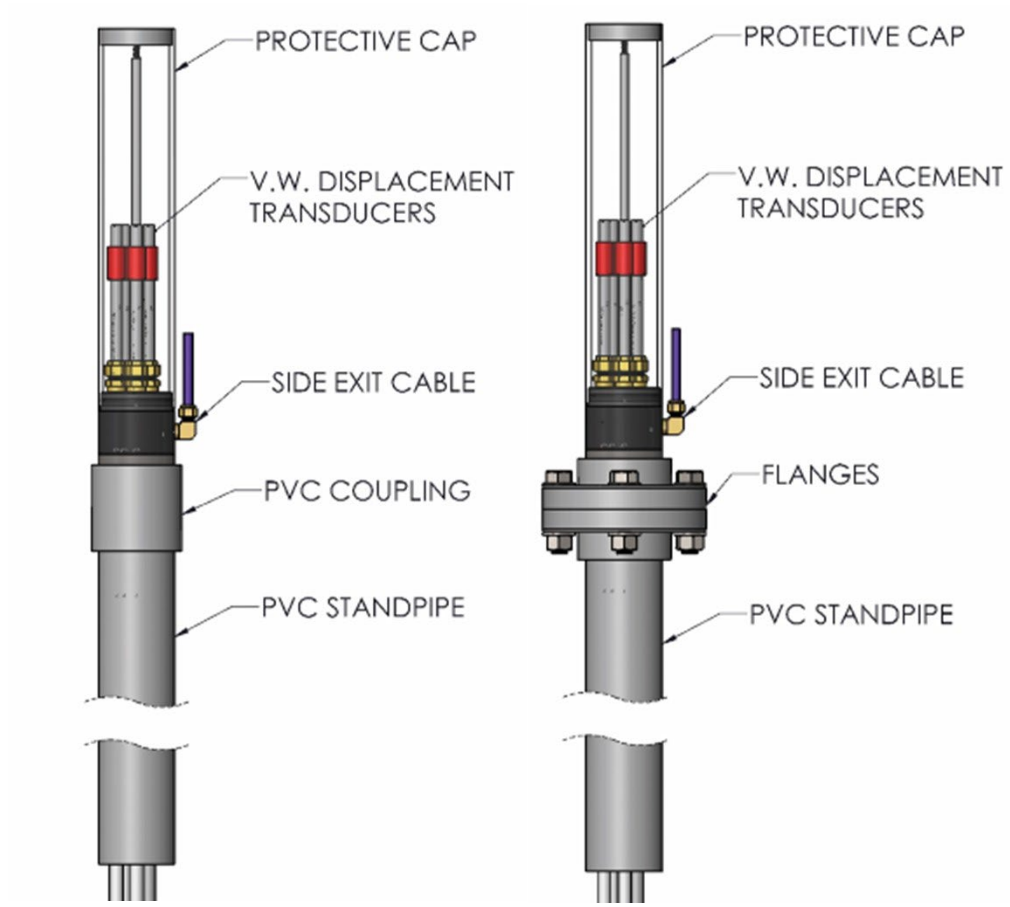

Figure 2 - Main Components of the Head Assembly

Head assembly sizes vary and are dependent upon the quantity and range of VW displacement transducers. (See appendix A.4 Head Assembly for more information.) The head assembly may be located above grade, recessed in a borehole, or seated in an enlarged section of the borehole known as an overcore.

1.2.2 Coupling, Standpipe, and Flange

A standpipe is cemented into the bore hole and is connected to the head assembly either with a PVC coupling or a set of PVC flanges. A custom bladder anchor can replace the tube mount and standpipe. This is recommended for upward installations.

The head can be attached to the standpipe by gluing the PVC coupling on the head assembly to a PVC standpipe inserted into the borehole. Two flanges can also be used (glued to the head and the standpipe ahead of time) which are bolted together. The standpipe and coupling, or flange/coupling assembly, are installed into the borehole. If using a coupling, the standpipe and coupling would be cemented in place and left to set up. With the standpipe secured in place, the MPBX string is lowered into the borehole through the standpipe and then the tube mount is glued into the coupling or flange.

1.2.2.1 Inline Slip Couplings

The inline slip couplings are attached to individual rod columns by cementing the coupling to the TUB-101 PVC pipe or using a barb fitting (on each end of the coupling) to attach the coupling to the TUB-103 or TUB-109 ½-inch tubing. Both types are shown below and come with a 10-cm or 30-cm range of motion. Multiple units in a single column can be implemented if desired. The range of motion allows compression (or extension) of the rod column in settlement (or heave) situations. Without the range of motion, there might be substantial bending or breaking of the PVC tubing or coiling of the rod column, which would introduce errors in the measured movement. They can be set anywhere in their range and are shipped with dissolvable tape to wrap around the slip location to temporarily hold it until the stainless steel or fiberglass rods can be locked. They are usually installed just below the head assembly but can be placed anywhere along the column. These couplings would be recommended where there is more than 1 inch of compressive movement. However, other considerations including grout stiffness, hole diameter, and installation depth can influence decisions on the use of slip couplings. Using a slip joint may also be considered where separation of the pipe or tube column under significant extension situations would be undesirable.

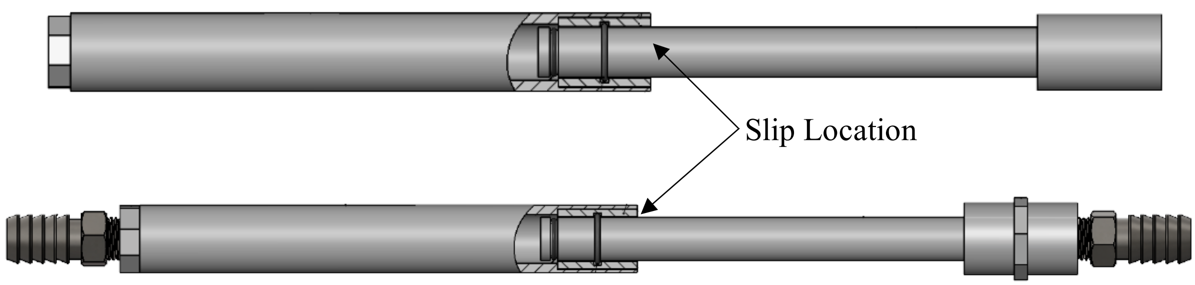

Figure 3 - Slip Location for Inline Slip Couplings

1.2.3 Vibrating Wire Displacement Transducers

GEOKON Model 4450 Vibrating Wire Displacement Transducers consist of a vibrating wire sensing element, in series with a heat treated, stress relieved spring. One end of the spring is connected to a vibrating wire, the other end to the transducer shaft. Movement of the anchors and attached connecting rods cause the spring inside the transducer to expand or contract, which changes the tension in the vibrating wire. The change in tension (strain) of the wire is directly proportional to the movement of the head relative to the anchors or vice versa.

The standard ranges of VW displacement transducer which can be installed in the extensometer are: 12.5 mm (0.5 inch), 25 mm (1 inch), 50 mm (2 inch), 100 mm (4 inch), 150 mm (6 inch), 200 mm (8 inch) & 300 mm (12 inch).

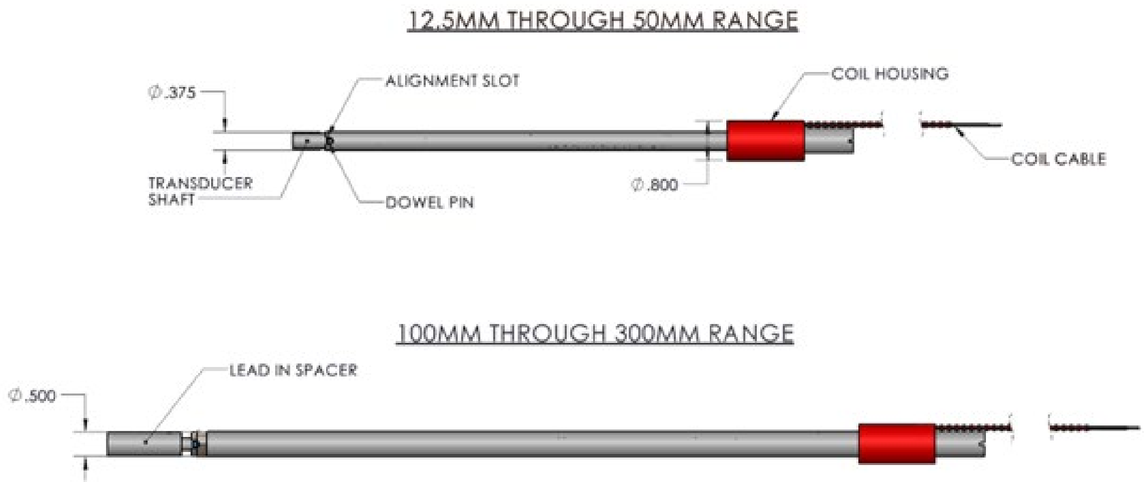

Figure 4 – Model 4450 Displacement Transducer

1.2.4 Connecting Rods

Connecting rods connect the borehole anchors to the displacement transducers located in the head assembly. There are 2 standard types of connecting rods available, fiberglass and stainless steel. Graphite rods are available as a custom option. Graphite rods are used for applications where thermal fluctuations can potentially influence rod behavior, as these rods have a significantly lower thermal coefficient of expansion than steel or fiberglass.

1.2.4.1 <u>Stainless Steel Rods</u>

The standard stainless steel connecting rods are made from 1/4-inch stainless steel rod sections, flush coupled to form a continuous string. Standard lengths are 5 ft and 10 ft but are available in lengths necessary for installation. They are encased in rigid PVC pipe, which protects them from grout (where applicable) thereby ensuring their ability to move freely as they are acted upon by forces along the axis of the instrument..

1.2.4.2 <u>Fiberglass Rods</u>

The standard fiberglass connecting rods are made from continuous length, 1/4-inch fiberglass. The rods are encased in polyethylene tubing for borehole lengths less than 30 meters (100 feet), and nylon tubing for borehole depths greater than 30 meters (100 feet). Fiberglass rods are typically not recommended for installations of 30 meters (100 feet) or greater. The tubing protects them from grout (where applicable) thereby ensuring their ability to move freely as they are acted upon by forces along the axis of the instrument.

The flexibility of the rods and tubing allows the extensometer to be preassembled and coiled at the factory for shipment to the jobsite where it can be uncoiled and inserted into the borehole. This greatly speeds up the installation process.

Note: Fiberglass rods have a lower modulus of elasticity than stainless steel rods. This, combined with friction effects, may lead to insufficient precision in applications where high resolution (< 0.1 mm) is required. Fiberglass rods are more stable thermally and can be a better choice than stainless steel rods in areas where temperatures may vary.

1.2.5 Borehole Anchors

Borehole anchors are installed at predetermined depths. The deepest anchor is normally installed in stable ground so that it can serve as a nonmoving point of reference for the rest of the anchors. There are three types of anchors available: groutable, hydraulic bladder, and hydraulic borros.

1.2.5.1 Groutable Anchors

Groutable anchors are usually recommended for downward directed boreholes or holes that must remain sealed. Each groutable anchor is made from a 229 mm (9 inch) length of #6 steel reinforcing bar. For stainless steel and fiberglass rods, the anchors are attached to the connecting rod with a Swagelok connector on the bottom using a through-hole in the rebar. PVC tubes are connected to the top of the anchors using the PVC adapter shown below, and tubing for fiberglass rods are connected to the top of the anchors using the barb connector. See Figure 5 below.

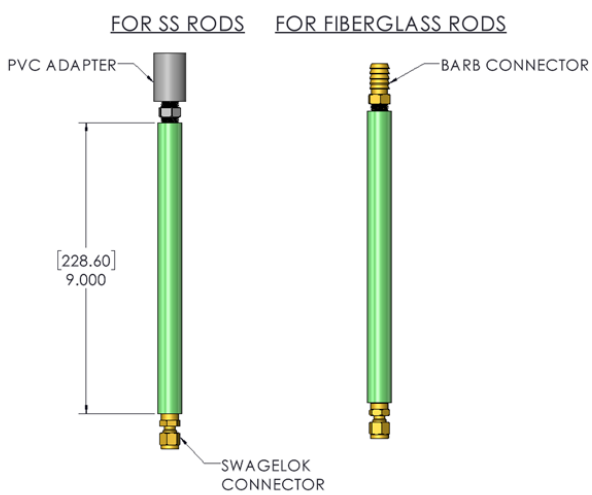

Figure 5 - Groutable Anchors

1.2.5.2 Hydraulic Bladder Anchor

Hydraulic bladder anchors use friction to secure the anchor to the borehole wall. They are designed to be used in all kinds of rock materials and dense soil. These anchors can be easily installed in boreholes oriented in any direction, which make them particularly useful in boreholes which are difficult to grout, such as fractured boreholes or ones which are oriented upwards.

The anchor comprises a spool of high strength plastic with a sealed copper bladder wrapped around the outside diameter. The bladder has a high-pressure nylon inflation line and built-in check valve. A hydraulic pump is used to inflate the copper bladder, causing it to expand and unwind. The soft copper material of the bladder allows it to deform and fill the space between the plastic spool and the borehole wall, thus wedging the anchor in place. The deformation of the copper bladder is permanent; and the anchor will stay in place even if the check valve fails.

Hydraulic bladder anchors are designed for customer-specified borehole sizes. Like the groutable anchor there is a through-hole in the anchor that allows the rod to attach to a Swagelok on the bottom side.

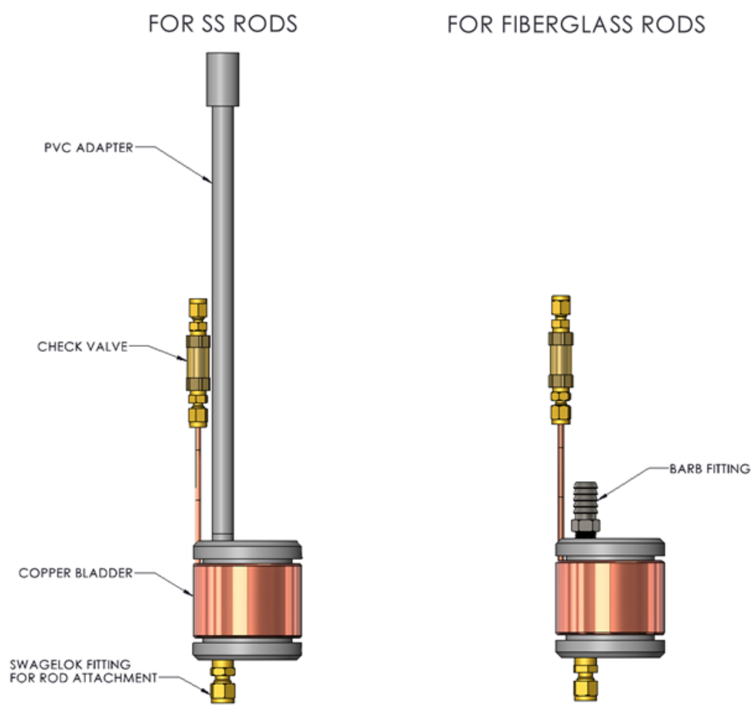

Figure 6 - Hydraulic Bladder Anchors

1.2.5.3 Single or Double Hydraulic Borros Anchor

Hydraulic borros anchors are a type of end-bearing anchor recommended for soft soils. Hydraulically actuated prongs, spaced 120º from one another, penetrate the walls of the borehole, ensuring positive end-bearing anchorage. Single borros anchors (Figure 7) have three prongs located on the bottom end of the anchor; double borros anchors (Figure 8) have an additional three prongs on the top end of the anchor. On both models, the prongs protrude approximately 150 mm from the anchor body when actuated.

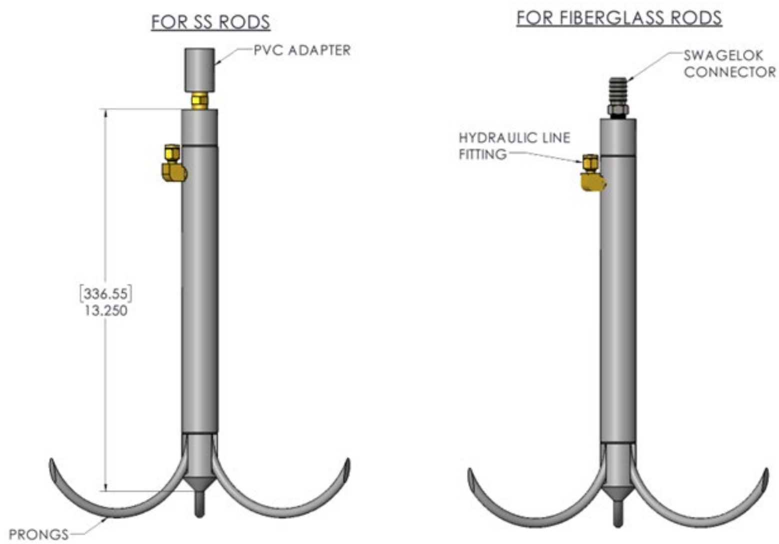

Figure 7 - Single Hydraulic Borros Anchors

For SS and Rods For Fiberglass Rods

Figure 8 - Double Hydraulic Borros Anchors

2 INSTALLATION CONSIDERATIONS

2.1 Tools

2.1.1 P/N 1100-TOOLKIT (Set of installation tools)

Part Number	Description	Quantity
ADH-103	Loctite 271 Thread locker	1
SUP-802	Black Electrical Tape	2
SUP-814	Fiber Tape	2
TLS-100	¼ inch x 4 inch Flat Head Screwdriver	1
TLS-106	#2, 4 inch Phillips Head Screwdriver	1
TLS-205	Log Arm Allen Wrench 3/16 inch	1
TLS-206	9/16 inch Wrench	2
TLS-216	Curved Jaw Vise Grips With Wire Cutter	2
TLS-300	Hacksaw with Blade	1
TLS-301	24 TPI Hacksaw Blades (Gray Stripe)	1
TLS-400	Flat 8 inch File	1
TLS-401	Handel for Hand File	1
TLS-601	Acid Brush (144 count Pack)	12
TLS-619	20 inch Toolbox	1

2.1.2 P/N 1100-RECESSED-TOOLS (Accessories for recessed installations)

Part Number	Description	Quantity
B4450-49	Setting Tool Wrench	1
HRD-A1663	3/16 inch T-handle Allen wrench, 25 inches Long	1

2.1.3 P/N 1100-GROUT-DOWN (Accessories for inclined downward installations)

Part Number	Description	Quantity
HRD-A1064	Hose Barb, 5/8 inch x1/2 inch, NPT	1
HRD-A1068	Gate Valve, ½ inch, Bronze, NPT	1

2.1.4 P/N 1100-GROUT-UP (Accessories for overhead/upward installations)

Part Number	Description	Quantity
A1150-69-5	Down Hole Grout Tube, 36 inches Long	1
A1150-70-1	External Grout Pipe, 24 inches Long	1
HRD-A1065	Hex Reducer Bushing	1
HRD-A1066	Close Nipple, 1/2 inch, Brass	1
HRD-A1067	Tee, 1/2 inch, Female, Brass	1
HRD-A1068	Gate Valve, 1/2 inch, NPT, Bronze	1
SWG-129B	B-400-1-4, Drilled 0.266 Through	1

2.2 Borehole Diameter

Boreholes should be drilled slightly deeper than the deepest anchor and cleared of debris before use. The mouth of the borehole can be enlarged (over-cored) or left as is, depending on installation requirements of the extensometer and project.

2.2.1 Extensometers without an Over Core

The minimum borehole diameter for extensometers without an over core is determined by the number of points included in the head assembly. Use Table 1 to determine the minimum borehole diameter for protruding head assemblies (Figure 9) and Table 2 to determine the minimum borehole diameter for recessed head assemblies (Figure 10).

NOTE: When grouting a borehole, the specified diameter may need to be increased to allow a sufficient amount of grout to be applied around the standpipe (The standpipe may already be cemented in place, or a standpipe may not be used.)

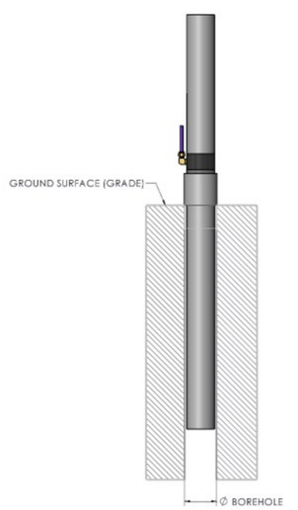

Figure 9 - Protruding Above the Borehole

# of Points	Min. Borehole Diameter
1-2	73 mm (2.88 inch)
3-4	89 mm (3.50 inch)
5-6	115 mm (4.50 inch)

Table 1 - Minimum Borehole Diameter for Protruding Extensometers

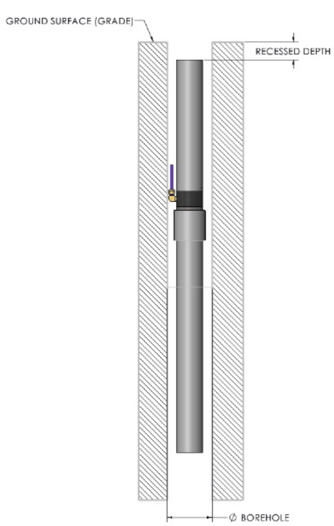

Figure 10 - Recessed in the Borehole

# of Points	Min. Borehole Diameter
1-2	125 mm (4.92 inch)
3-4	141 mm (5.54 inch)
5	176 mm (6.92 inch)
6	184 mm (7.22 inch)

Table 2 - Minimum Borehole Diameter for Recessed Extensometers.

Note: For ease of installation the borehole can be larger than the minimum diameter shown above.

2.2.2 Extensometers Recessed in an Over Core Borehole

2.2.2.1 Over Core Depth

The over core depth can be determined using Table 3. Table 3 references the length of the head assembly, which can be determined using the information in Appendix A, Section A.4 Head Assembly.

NOTE: If the top of the head assembly will be recessed below the ground surface, or if back fill will be placed above the top of the head assembly, add the distance from the ground surface to the top of the protective cap to the measurement given in Table 3 to calculate the total over core depth. If the optional cable exit from the top of head is used, then the depth should be increased to account for cable. See the Figure 11.

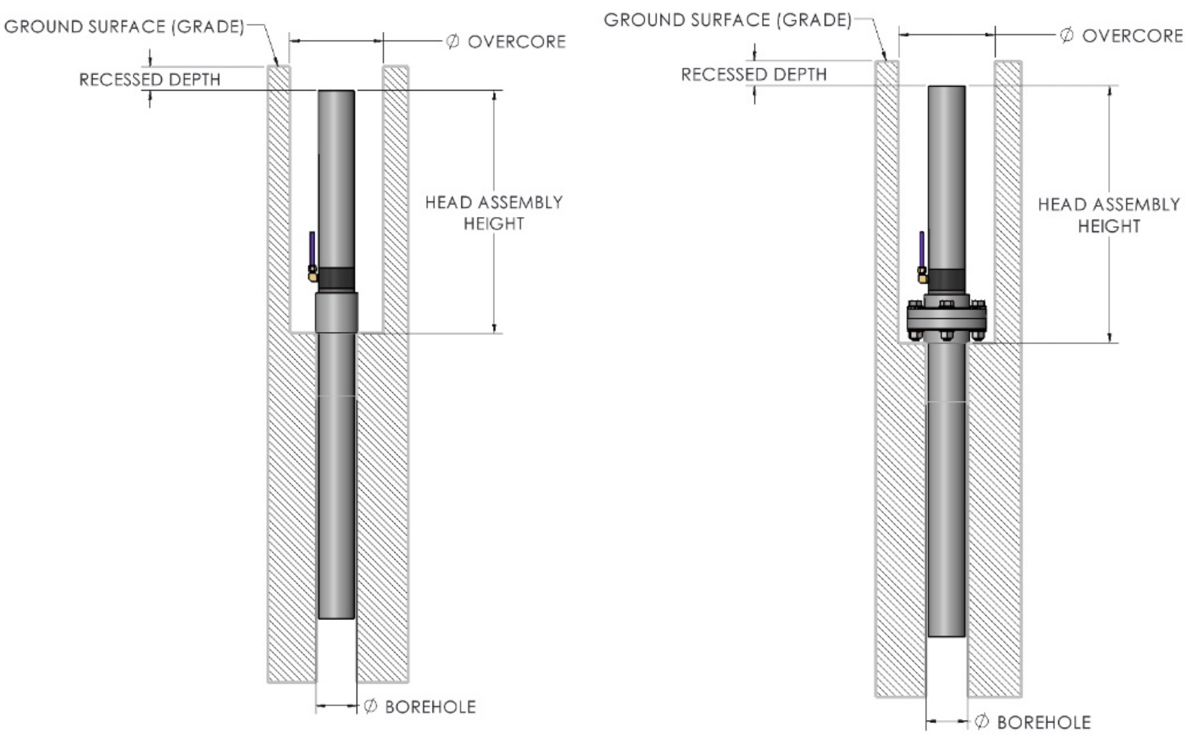

Figure 11 - Over Core Depth

Number of Points	Transducer Range (VW)	Head Assembly Length NO FLANGE	Head Assembly Length WITH FLANGE
1-2	12.5, 25, 50 mm (0.5, 1, 2 inch)	364 mm (14.38 inch)	384 mm (15.13 inch)
	100, 150 mm (4, 6 inch)	466 mm (18.38 inch)	485 mm (19.13 inch)
	200 mm (8 inch)	625 mm (24.63 inch)	625 mm (24.63 inch)
	300 mm (12 inch)	778 mm (30.63 inch)	778 mm (30.63 inch)
3-4	12.5, 25, 50 mm (0.5, 1, 2 inch)	368 mm (14.47 inch)	384 mm (15.13 inch)
	100 mm (4 inch)	444 mm (17.47 inch)	485 mm (19.13 inch)
	200 mm (8 inch)	608 mm (23.97 inch)	625 mm (24.63 inch)
	300 mm (12 inch)	761 mm (29.97 inch)	778 mm (30.63 inch)

5-6	12.5, 25, 50 mm (0.5, 1, 2 inch)	378 mm (14.88 inch)	381 mm (15.00 inch)
	100 mm (4 inch)	479 mm (18.88 inch)	482 mm (19.00 inch)
	200 mm (8 inch)	619 mm (24.38 inch)	622 mm (24.05 inch)
	300 mm (12 inch)	772 mm (30.38 inch)	775 mm (30.50 inch)

Table 3 - Head Assembly Length

2.2.2.2 Over Core Diameter

The minimum over core diameter for extensometers protruding above the borehole (Figure 12) is determined by the number of points included in the head assembly and if a coupler or flange is used. Use Table 4 below to determine the minimum over core diameter for using a flange, and Table 2 for a coupler only. Over core diameter should be larger than the flange diameter.

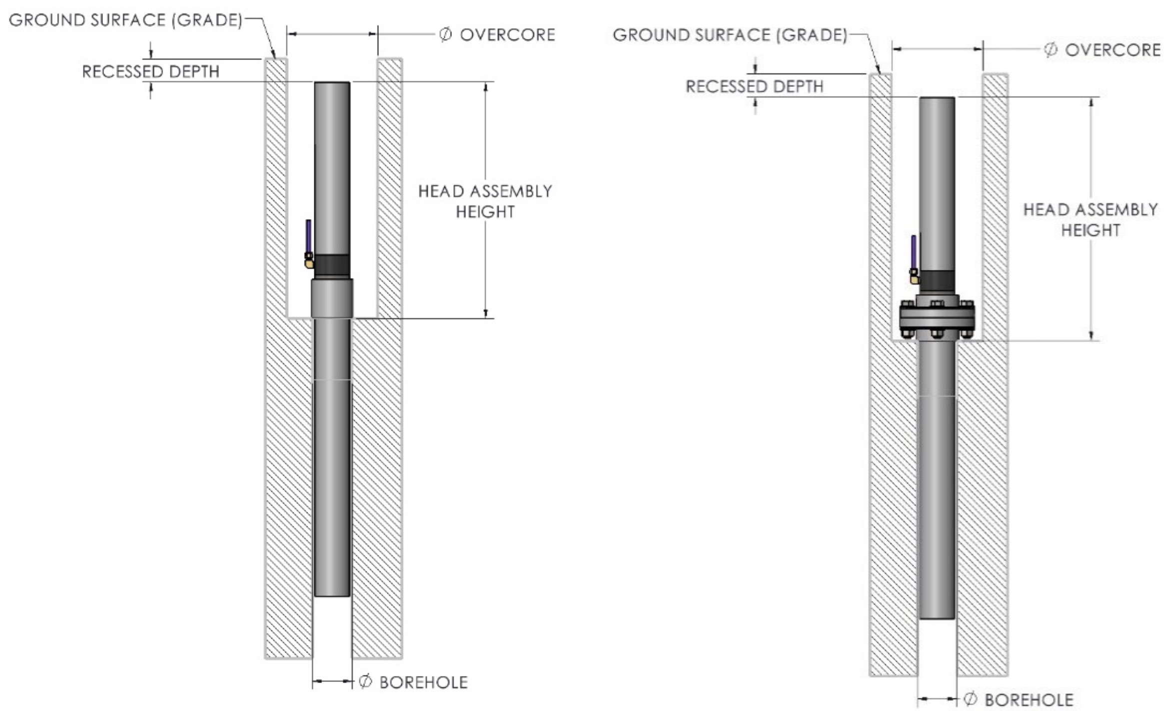

Figure 12 - Over core Diameter

Number of Points	Flange Diameter (overcore should be larger than the flange dimeter)
1-2	178 mm (7 inch)
3-4	191 mm (7.50 inch)
5-6	230 mm (9.06 inch)

Table 4 - Minimum Over Core Diameter

2.3 Anchor Spacing

Anchor spacing may be dictated by geologic features or specific zones that need to be monitored. If possible, the deepest anchor should be installed in stable ground so that it can serve as a nonmoving reference point for the head and the rest of the anchors. For extensometers installed from within tunnels, the deepest anchor should be installed at least two tunnel diameters away from the tunnel wall.

Anchor depths are typically measured from the installation surface to the bottom tip of the anchor, as illustrated in Figure 13.

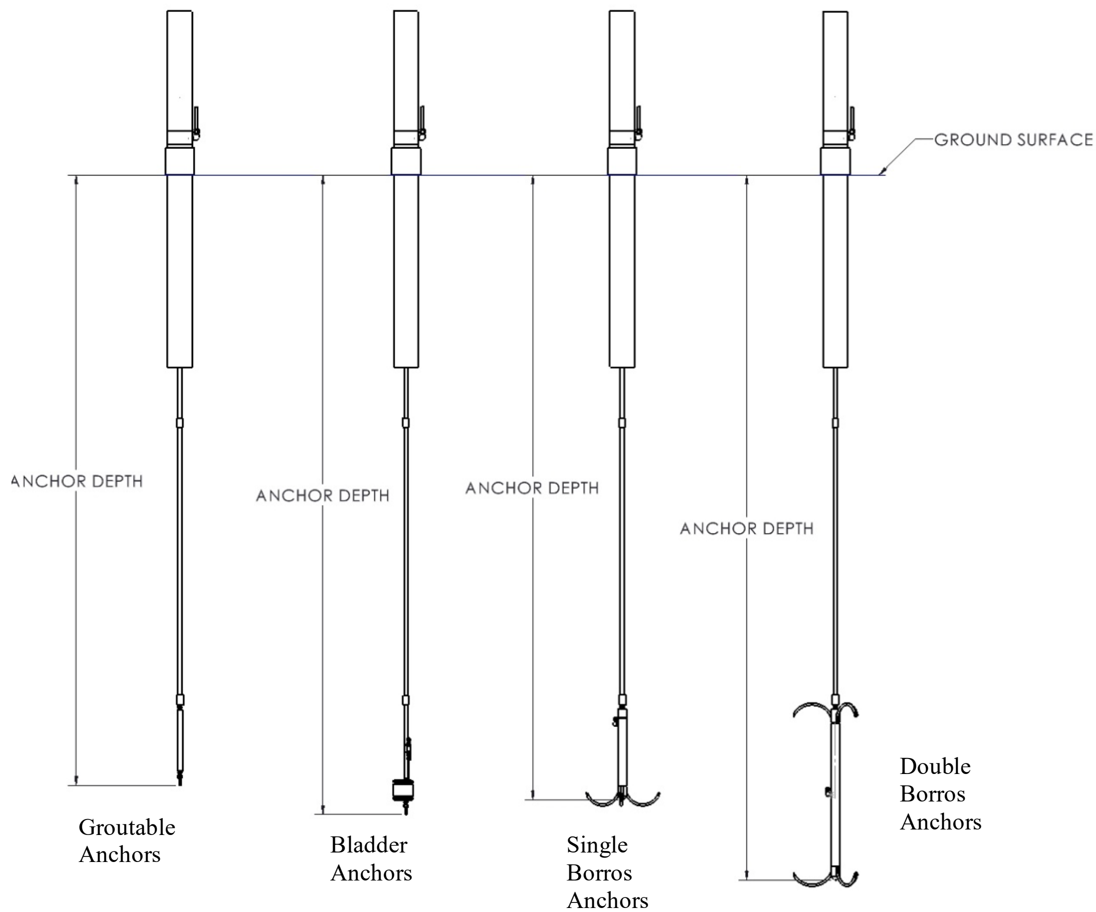

Figure 13 - Anchor Depths

2.4 Cable Installation and Splicing

The cable should be routed to minimize the possibility of damage due to moving equipment, debris or other causes. The cable can be protected using flexible conduit, which can be supplied by Geokon.

Terminal boxes with sealed cable entries are available from Geokon for all types of applications. These allow many gauges to be terminated at one location with complete protection of the lead wires. The interior panel of the terminal box can have built-in jacks or a single connection with a rotary position selector switch. Contact Geokon for specific application information.

Because the vibrating wire output signal is a frequency rather than a current or voltage, variations in cable resistance have little effect on gauge readings; therefore, splicing of cables has no ill effects, and in some cases may in fact be beneficial. The cable used for making splices should be a high-quality twisted pair type, with 100% shielding and an integral shield drain wire. When splicing, it is very important that the shield drain wires be spliced together. Always maintain polarity by connecting color to color.

Splice kits recommended by Geokon incorporate casts, which are placed around the splice and are then filled with epoxy to waterproof the connections. When properly made, this type of splice is equal or superior to the cable in strength and electrical properties. Contact Geokon for splicing materials and additional cable splicing instructions.

Cables may be terminated by stripping and tinning the individual conductors and then connecting them to the patch cord of a readout box. Alternatively, a connector may be used which will plug directly into the readout box or to a receptacle on a special patch cord.

3 ASSEMBLY AND INSTALLATION

PLEASE NOTE: PVC primer and cement must be obtained locally. Airfreight restrictions prohibit GEOKON from shipping these materials.

3.1 Preparation

Prepare an area near the borehole for unpacking and assembling the extensometer. This should be done on a flat, dry surface, which has been covered with blankets, tarps, or similar. Use caution when unpacking the extensometer to avoid damaging sensitive components.

Check through all supplied components to verify that materials match the items ordered and are the correct quantity. Assemble with the lowest anchor oriented toward the borehole, because this end will go in first.

3.2 Connecting Rod Assembly

If stainless steel connecting rods are used, continue to Section 3.2.1. If fiberglass connecting rods are used, see Section 3.2.2, For All Anchor Types.

First thread the guide tube into the tube mount. Then slide the guide tube into the downhole side of the tube mount. Then attach the guide tubes with hose barbs into the downhole side of the tube mount.

Note: The anchor mounting points on the tube mount are numbered. The shallowest anchor should be attached to mounting point #1, with the remaining anchors attached in order, with the deepest anchor coinciding with the highest number.

3.2.1 Stainless Steel Connecting Rods

Using two pairs of locking pliers, assemble the connecting rod lengths on the clean ground surface using the connecting rod table provided with the extensometer. The assembly area should be clean of debris and long enough to accommodate the assembly of the entire length of the extensometer.

Apply thread locker to all the threaded connections. Wipe excess thread locker off joints to prevent rods from gumming up inside the PVC pipes. Alternate assembly of rods and protective PVC tubing as described below. If the extensometer is assembled over a long day where significant temperature changes are expected, the PVC pipe will contract and expand accordingly and could change length.

For Groutable or Bladder Anchors: Slide the female end of the connecting rod through the anchor, until it protrudes 25 mm (1 inch) beyond the Swagelok connector. Tighten the Swagelok connector nut per the instructions in APPENDIX D. SWAGELOK TUBE FITTING INSTRUCTIONS. Figure 14 and Figure 15 show the completed assemblies.

For Borros Anchors: Using thread locker, screw the female threaded end of the connecting rod onto the setscrew located in the top of the Borros anchor. Figure 16 shows the completed assembly.

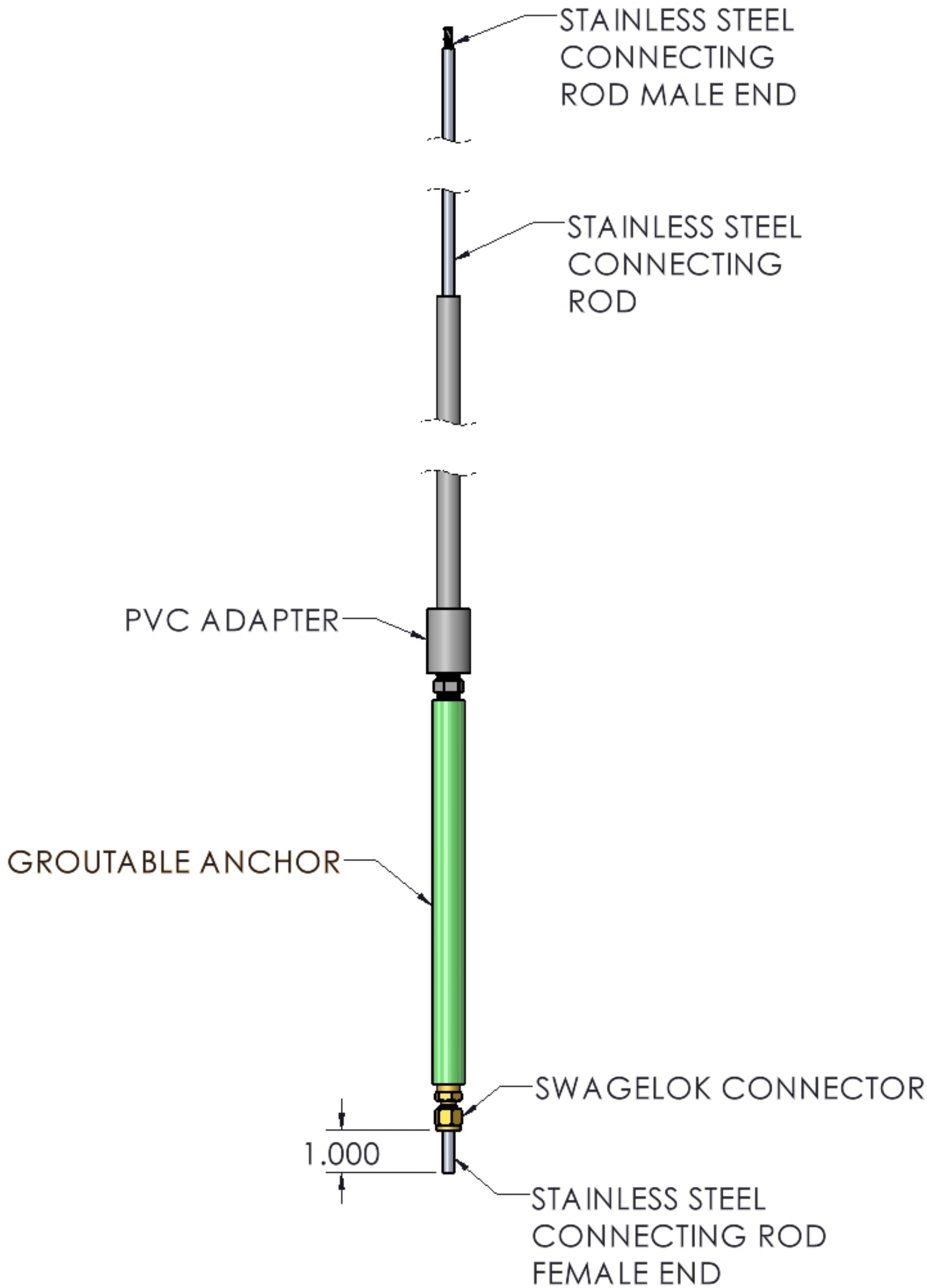

Figure 14 - Groutable Anchors

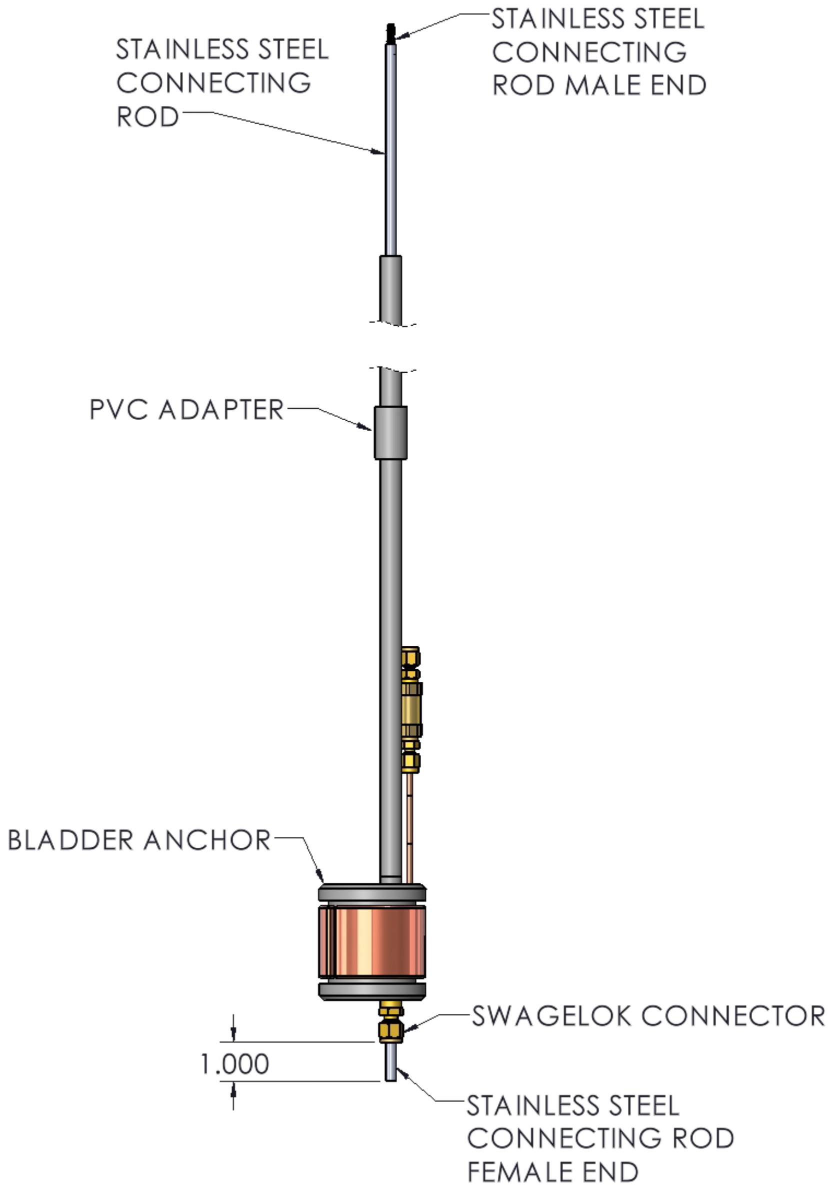

Figure 15 - Bladder Anchors

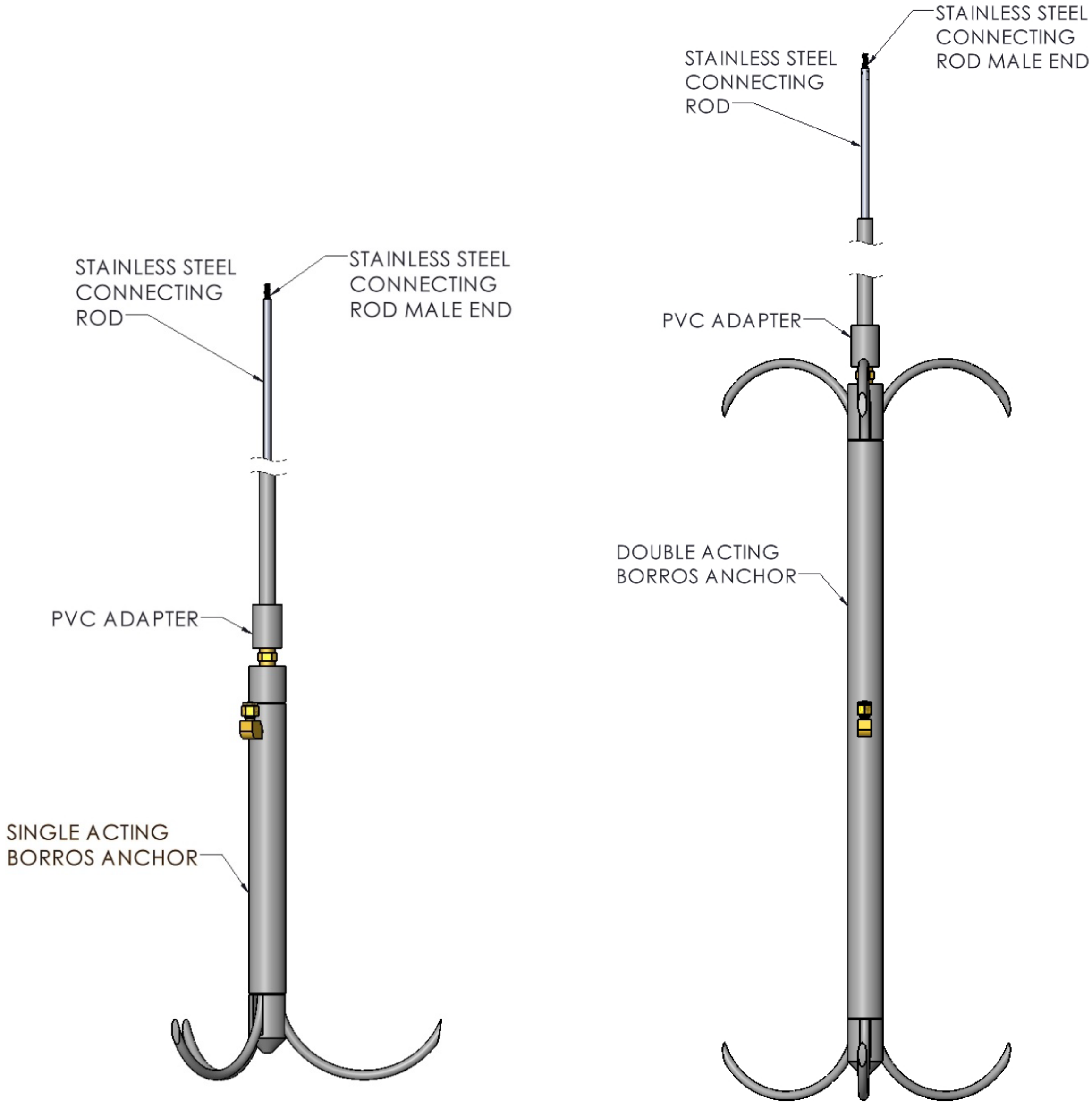

Figure 16 Borros Anchors

3.2.2 For All Anchor Types:

Slide one, 0.54 inch outside diameter 1/4 inch SCH 40 PVC pipe over the completed connecting rod column. Alternate attaching SS rods and PVC pipe based on desired depth. Glue the pipe into the adapter coupling on top of the anchor using PVC primer and cement. Allow sufficient time for the cement to harden. (In cold weather, it may be advisable to warm the connector with a propane torch.)

Continue to add lengths of 6 mm (1/4 inch) diameter PVC pipe and couplings using PVC primer and cement on each joint. Primer should be added to both ends of the pipes and the interior of the couplers. PVC cement should only be applied to the pipe ends, and not the interior of the coupler. This reduces the potential for pushing cement inside the pipe and onto the rods, which may inhibit movement of the rods. The final section of PVC pipe extending from each anchor needs to be cut ***before it's cemented into the last PVC coupling***. Cut the PVC tube so that the connecting rod is beyond the end of the PVC pipe, as indicated in Table 5 (shown in Figure 17.)

Transducer	12.5 mm	25 mm	50 mm	100 mm	150 mm	200 mm	300 mm	
Stainless Steel	152	132	66	259	196	246	348	**mm**
	6.0	5.2	2.6	10.2	7.7	9.7	13.7	**Inches**
Fiberglass	180	160	94	287	224	274	376	**mm**
	7.1	6.3	3.7	11.3	8.8	10.8	14.8	**Inches**

Table 5 – Cutback Length

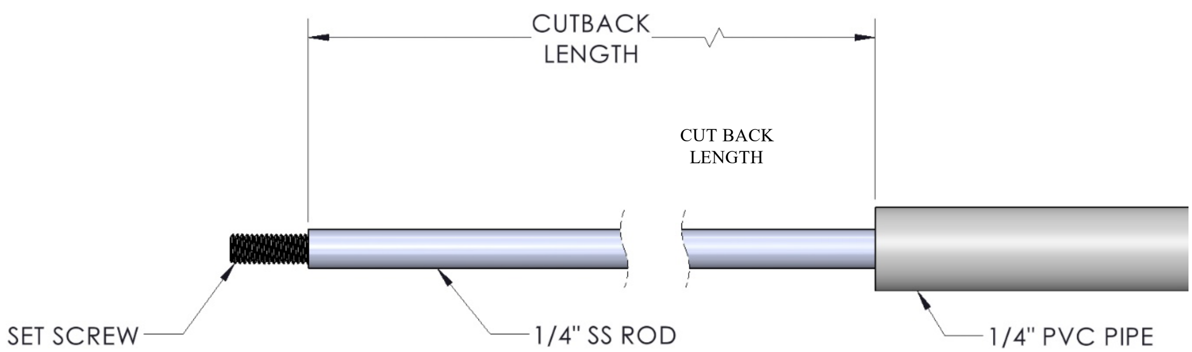

Figure 17 – Stainless Steel Cut Back Length

Note: 1, 3, and 5 point heads will have one port that is not used. Apply PVC primer and cement into the reduction bushing socket, which is located at the end of the guide tube and the trimmed PVC pipe. Next, feed the connecting rod into the guide tube until the 1/4-inch PVC pipe is fully seated in the reduction bushing.

Skip to Section 3.3 for the next step of the installation process

3.2.3 Fiberglass Connecting Rods

To uncoil the bundle of fiberglass rods, carefully cut one tape wrapping after another, sequentially around the bundle. **Do not try to cut more than one tape joint at a time!** The coiled extensometer behaves like a tight spring and can unwind violently if the tape restraints are not removed sequentially. Lay the uncoiled rod assembly out on the prepared surface next to the borehole.

Trim the 13 mm (0.5 inch) diameter poly tubing per Table 5 – Cutback Length above.

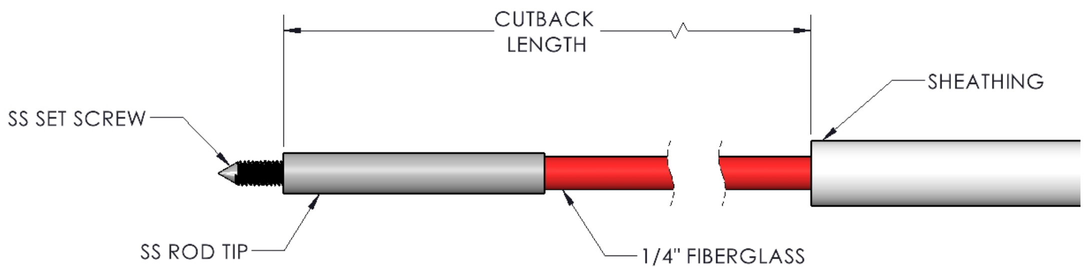

Figure 18 – Fiberglass Cut Back Length

Pass the fiberglass rod tips through the hose barbs in the tube mount guide tubes.

Push the trimmed poly tubing onto the barb fitting. This may require *gentle* heating of the tubing with a heat gun or suitable device. Only a small amount of heat is necessary to make it flexible enough to slide over the fitting. **Caution! Overheating the tubing can cause the tubing to not adhere properly to the barb fitting.**

3.3 Attach Extension Rods to Connecting Rod Column

Slide the supplied extension rod through the top of the tube mount and tighten it onto the connecting rod column, **finger tight only**. The extension rod will be removed later in the process. Next, slide the Swagelok male connector over the extension rod and thread it into the tube mount. Tighten the Swagelok nut, compressing the nylon ferrules, to secure the extension rod and rod column in the tube mount. Repeat this process for the remaining rod columns. This should be done only when the assembly is ready to be installed, to help minimize thermally induced stress on the joints of the rod system. Thread the eyebolts into the top of the tube mount and install the green plugs into the threaded holes to keep Debris from getting in the threads.

3.4 Install Hydraulic Lines (Hydraulic Actuated Anchors Only)

Slide the hydraulic line through the hydraulic line hole in the tube mount. Leave enough hydraulic line protruding above the tube mount to attach the hydraulic pump. Lines should be labeled with respect to the corresponding anchor.

3.5 Bundle the Rods and Anchors Together

If desired, use nylon filament tape (provided if the separate tools line was purchased) to **loosely** bundle the rod and anchor assemblies together. Start at the head assembly and work downward, applying tape every two meters (6 feet). **Caution! Do not** tape directly over the anchors. If a grout tube is being used, do not tape it to the rest of the bundle. Each anchor tube should be independent and not bundled together tightly enough to limit grout encapsulation.

3.6 Install Grout Pipe (Grouted Boreholes/Casing Only)

Slide the grout pipe through the grout pipe hole in the tube mount until it extends beyond the deepest anchor. Using a hacksaw, cut a few small openings in the grout tube at 0.25 m intervals up from the tip of the grout pipe. This allows for additional discharge ports if the tip gets plugged during installation. Leave enough grout pipe protruding above the tube mount to attach the grouting equipment.

3.7 PVC Standpipe and Coupling Assembly

Glue the coupling to the standpipe first, and then apply quick setting (hydraulic) cement on the outside of the standpipe and insert it into the borehole to the desired depth. Hold the standpipe in place until the cement hardens. This can be accomplished using wooden wedges, sackcloth soaked in quick-setting cement, or other similar methods as required.

Note: Allow sufficient time for the cement to harden before installation of the extensometer.

3.8 Flange Installation

Optional flanges (2) may be ordered to rest at the top of the borehole. Bolt the two flanges together and glue them to the standpipe. Then insert the standpipe into the borehole and wedge it or cement it in place.

3.9 Lifting the Extensometer Assembly into the Borehole

Connect enough customer supplied rope or cable to the eyebolt(s) located in the top of the tube mount to suspend the extensometer assembly once it is in the borehole. Carefully move the extensometer assembly toward the borehole, create a large arc with the rod tubes of at least 3 meters (10 feet), and then lower the assembly into the borehole.

If a coupling (or flange) and standpipe assembly has been installed apply PVC primer/cement to it and the tube mount, then lower the extensometer until the tube mount is just above the coupling (or flange) and standpipe assembly. Apply PVC primer and glue to the tube mount and coupling (or flange), and then lower the tube mount into the coupling (or flange).

For boreholes using casing or hollow core augers, lower the extensometer until it has reached its predetermined elevation. Keep the extensometer suspended at this elevation until the steps in Section 3.10 have been completed.

3.10 Setting Anchors

3.10.1 Groutable Anchors

A cement-bentonite grout mix is suggested for backfilling the extensometer borehole. The cement-bentonite grout uses any kind of bentonite powder combined with Type I or Type II Portland cement. The exact amount of bentonite needed will vary. Grout mixtures should be determined based on the application and surrounding formation. Grout for soft soil installations should not have significant compressive or tensile strength, and likewise grout for hard soils or rock should not be of low strength. The water to cement ratio of grout mixtures control the strength and can be adjusted as needed for each application. Table 6 shows two suggested mixes for strengths of 50 psi and 4 psi.

	50 PSI Grout for Medium to Hard Soils		**4 PSI Grout for Soft Soils**	
	Amount	**Ratio by Weight**	**Amount**	**Ratio by Weight**
Water	30 gallons	2.5	75 gallons	6.6
Portland Cement	94 lb. (one sack)	1	94 lb. (one sack)	1
Bentonite	25 lb. (as required)	0.3	39 lb. (as required)	0.4
Note:	The 28 day compressive strength of this mix is about 50 psi, like very stiff/hard clay. The modulus is about 10,000 psi.		The 28 day strength of this mix is about 4 psi, like very soft clay.	

Table 6 - Cement / Bentonite / Water Ratios

Add the measured amount of clean water to the barrel then gradually add the cement in the correct weight ratio. Mix the cement thoroughly into the water, and then slowly add the bentonite powder so that clumps do not form. Keep adding bentonite until the watery mix turns to a slimy consistency. Continue mixing for approximately 5 to 10 minutes to allow the grout to thicken. Add more bentonite as required until it is a smooth, thick, creamy texture, similar to pancake batter,which is as heavy as it is feasible to pump.

Connect the gate valve assembly to the grout pump. It may be advisable to prime the grout tube and verify that it is not plugged by pumping water through the line before grouting.

Pump the grout into the borehole slowly, displacing any fluid (water or drilling fluid) left in the borehole. while slowly pulling the grout tube from the borehole. If the grout pipe is sacrificial it can be left in place.

If using a hollow core auger, or if the borehole has been lined with casing, remove the casing/hollow core auger from the borehole during grouting. Care should be taken to support the extensometer assembly during removal of the augers or casing sections.

Lastly, disconnect the grout pump from the gate valve assembly and then disconnect the gate valve assembly from the grout tube.

Allow enough time for the grout to fully cure before continuing with the installation. (allow grout to set for at least 1 day, but 3 days is best),

3.10.2 Hydraulic Anchors (Bladder and Borros Style)

Connect the hydraulic line to a hydraulic pump and apply pressure until a steady reading of 1500 psi is obtained for bladder anchors and 2500 psi for borros anchors.

If the borehole is to be grouted, follow the instructions in Section 3.10.1.

3.11 Remove Anchor Hardware

After all the anchors have been grouted or inflated, and any grout that has been placed has fully cured complete the following:

1) Loosen the temporary Swagelok connector nut(s) securing the extension rods to the top of the tube mount assembly.

2) Unscrew and remove the extension rod(s).

3) Remove the temporary Swagelok connector (s). Take care to clean debris from top of tubemount during this process to keep it from getting down inside the rod tubes.

4) Remove the rope/cable and eyebolts that were used to suspend the extensometer (if applicable).

5) Trim the grout tube and hydraulic lines so that they are flush or slightly below the face of the tube mount.

3.12 Attach the Transducer Housing Assembly

1) Clean the face of the tube mount.

2) Unscrew and remove the cap screw(s) in the protective cap, then separate the protective cap from the transducer housing. (You will experience some resistance when removing the protective cap due to the O-ring seal provided between the transducer housing and the protective cap.)

3) Make sure the tube mount and transducer housing are properly aligned by matching the numbers stamped on the tube mount with those on the transducer housing.

4) Bolt the transducer housing to the tube mount by sliding the three cap screws with O-rings into the holes in the transducer housing and then tightening them into the tube mount.

3.13 Installing the Vibrating Wire Transducers

To connect the vibrating wire transducers to the connecting rods, complete the following:

1) Select a transducer and record the following: the serial number, the extensometer number it is used in, and the specific anchor position.

2) Remove the shipping spacer from the transducer shaft (it will be a split plastic tube around the shaft or a dowel pin through the shaft). Allow the shaft of the transducer to gently retract until the metal pin that protrudes from the side of the shaft sits in the notch in the transducer housing.

   CAUTION! Never rotate the transducer shaft more than 180 degrees. This may cause irreparable damage to the instrument. The alignment pin on the transducer shaft and slot on the body serve as a guide for alignment. Never extend the transducer beyond its working range.

3) Loosen the nut on the #1 Swagelok fitting.

4) Push the transducer through the fitting until it engages the end of the connecting rod.

   Warning! Before completing this step, be sure the pin in the transducer shaft is securely seated in the notch on the transducer housing, otherwise the vibrating wire inside the gauge may break.

   Warning! Always make sure to keep downward force on the transducer during this process, so that upper portion of transducer doesn't disengage from lower portion.

5) Rotate the sensor clockwise until it is tight on the connecting rod (about 16 turns). If the transducer is not connecting with the rod below, because of a small misalignment, loosen the Swagelok from the transducer housing and slide it up on the transducer shaft. This allows more flexibility for better alignment. Then thread the Swagelok back in place.

6) Connect a readout box to the transducer leads to take a reading. (For instructions on operating a readout box, see Section 4 TAKING READINGS.)

7) While observing the display of the readout, gently pull up on the transducer shaft until the desired reading is obtained, based on the information below.

   The sensor range is approximately 4,000 digits of change, typically starting at 2,500 and ending at 6,500 (plus some over-range capability). To set the sensor at mid-range, the reading should be about 4,500. For 1/3 compression and 2/3 extension, approximately 3,500. For 1/3 extension and 2/3 compression, approximately 5,500. Consult individual calibration sheets for exact readings.

8) While holding the transducer shaft in the desired position, tighten the nut on the Swagelok fitting one full turn beyond the initial engagement (Custom wrenches are available for recessed heads as part of installation kit 1150-31). Initial engagement is when the force required to rotate the nut increases.)

9) Repeat the above process for the remaining transducers.

10) Connect the leads of the transducers to the leads of the extensometer cable located in the protective cap per the wiring charts shown in APPENDIX C. WIRING CHARTS FOR VIBRATING WIRE TRANSDUCERS using the provided **Posi-Lock Connectors**) as shown in Figure 19.

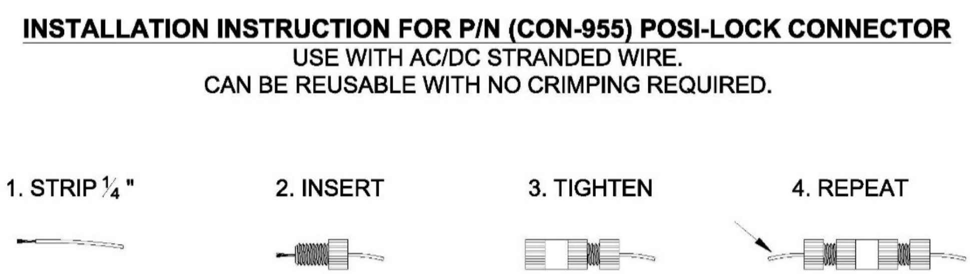

Figure 19 - Using Posi-Lock Connectors

11) Check that all the connections made between the leads are secure by gently pulling on them.

12) Connect the readout to the cable of the head assembly.

13) Observe the displayed readout. The reading for each transducer should be close to what was observed in Step 8. The temperature displayed should match the ambient temperature.

14) Reinstall the protective cap over the transducer housing and reinstall the capscrew(s) with O-ring and tighten.

3.14 Instrument Head protection

The instrument head should be protected from damage wherever possible. This may require recessing the instrument head inside the borehole to avoid blasting or construction-related damage. In exposed locations a protective enclosure can be constructed to ward against falling objects, moving equipment, and vandalism.

Extensometer head assemblies installed downwards from street level are best contained within manholes with access covers. The manhole should be large enough to accommodate the instrument head and any datalogger that may be in use. The manhole should be installed with a drain so that it does not fill with water.

4 TAKING READINGS

An important note: For MPBX models designed for electronic readout only, when a rod is pulled the transducer shaft will extend, and the vibrating wire reading will increase.

The most important reading is the first reading; it is the base reading to which all subsequent readings will be compared. Most installations are subject to a **bedding-in** process during which slight movements can occur. These movements generally cease after two or three days but can sometimes take longer.

All readings should be compared with previous readings as soon as they are taken. In this way, sudden changes of readings can be instantly checked to see if they are real or a reading error. If the changes are real, the observer is alerted to the possibility of serious ground movements, or to possible instrument damage, and can look for further evidence of either.

4.1 Electronic Readings

4.1.1 Readout Box

For detailed information see the manual that came with your readout box.

5 TROUBLESHOOTING

Maintenance and troubleshooting of extensometers are confined to periodic checks of cable connections and maintenance of terminals. Once installed, the instruments are usually inaccessible and remedial action is limited. Should difficulties arise, consult the following list of problems and possible solutions. For additional troubleshooting and support, contact Geokon.

Symptom: Thermistor resistance is too high:

- ✓ There may be an open circuit. Check all connections, terminals, and plugs. If a cut is located in the cable, splice according to instructions in section 2.4.

Symptom: Thermistor resistance is too low:

- ✓ There may be a short. Check all connections, terminals, and plugs. If a short is located in the cable, splice accordingly.

- ✓ Water may have penetrated the interior of the head. There is no remedial action.

Symptom: Instrument Readings are Unstable:

- ✓ Is the readout box position set correctly? If using a datalogger to record readings automatically, are the swept frequency excitation settings correct?
- ✓ Is the transducer shaft positioned outside the specified range (either extension or retraction) of the instrument? Note that when the transducer shaft is fully retracted with the alignment pin inside the alignment slot (as shown in Figure 4) the readings will likely be unstable because the vibrating wire is out of its specified range.
- ✓ Is there a source of electrical noise nearby? Likely candidates are generators, motors, arc welding equipment, high voltage lines, etc. If possible, move the instrument cable away from power lines and electrical equipment or install electronic filtering.
- ✓ Make sure the shield drain wire is connected to ground. Connect the shield drain wire to the readout using the blue clip. (Green for the GK-401.)
- ✓ Does the readout work with another gauge? If not, it may have a low battery or possibly be malfunctioning.

Symptom: Instrument Fails to Read:

- ✓ Is the cable cut or crushed? Check the resistance of the cable by connecting an ohmmeter to the gauge leads. **Error! Reference source not found.** on the following page shows the expected resistance for the various wire combinations; **Error! Reference source not found.** is provided to fill in the actual resistance found. Cable resistance is approximately 14.7 Ω per 1000' of 22 AWG wire. (Multiply this factor by two to account for both directions.)

  If the resistance is very high or infinite (megohms), the cable is probably broken or cut. If the resistance is very low (<20Ω), the gauge conductors may be shorted. If a cut or a short is located in the cable, splice according to the instructions in Section 2.4.

- ✓ Does the readout or datalogger work with another gauge? If not, it may have a low battery or possibly be malfunctioning.

APPENDIX A. SPECIFICATIONS

A.1 Model 1100 Specifications

Standard Ranges[1]	12.5, 25, 50, 100, 150, 200, 300 mm
Least Reading	0.025 mm
Borehole Diameter[2]	73 mm
Maximum Length	100 m

Table 7 - A-3 Extensometer Specifications

[1]The minimum borehole diameter increases with the addition of more measuring points. Please refer to the Model 1100 data sheet for more information.
[2]Other ranges available on request.

A.2 Rod Specifications

Material	Diameter	Weight per Meter	Young's Modulus	Temperature 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

Table 8 - Rod Specifications

A.3 Model 4450 Vibrating Wire Transducer Specifications

Standard Ranges[1] **(mm)**	12.5, 25, 50, 100, 150, 200, 300
Resolution[2]	0.025% F.S.
Linearity	0.25% F.S.
Thermal Zero Shift[3]	< 0.05% FSR/°C
Stability	< 0.2%/year (under static conditions)
Accuracy[4]	±0.1% F.S.
Overrange	115%
Temperature Range	-20 to +80 °C
Frequency Range	1400 - 3500 Hz
Coil Resistance	180 Ω, ±10 Ω
Cable Type[5]	Two twisted pair (four conductor) 22 AWG Foil shield, PVC jacket, nominal OD=6.3 mm (0.25 inch)

Table 9 - Model 4450 Displacement Transducer Specifications

Notes:
[1] Other ranges are available on request.
[2] Minimum; greater resolution possible depending on readout.
[3] Depends on application.
[4] Accuracy established under laboratory conditions.
[5] Polyurethane jacket cable available.

A.4 Head Assembly Dimensions

The dimensions of the Head Assembly of an extensometer can be calculated using **Figure 22** and **Table 12.**

OPTIONAL FLANGE

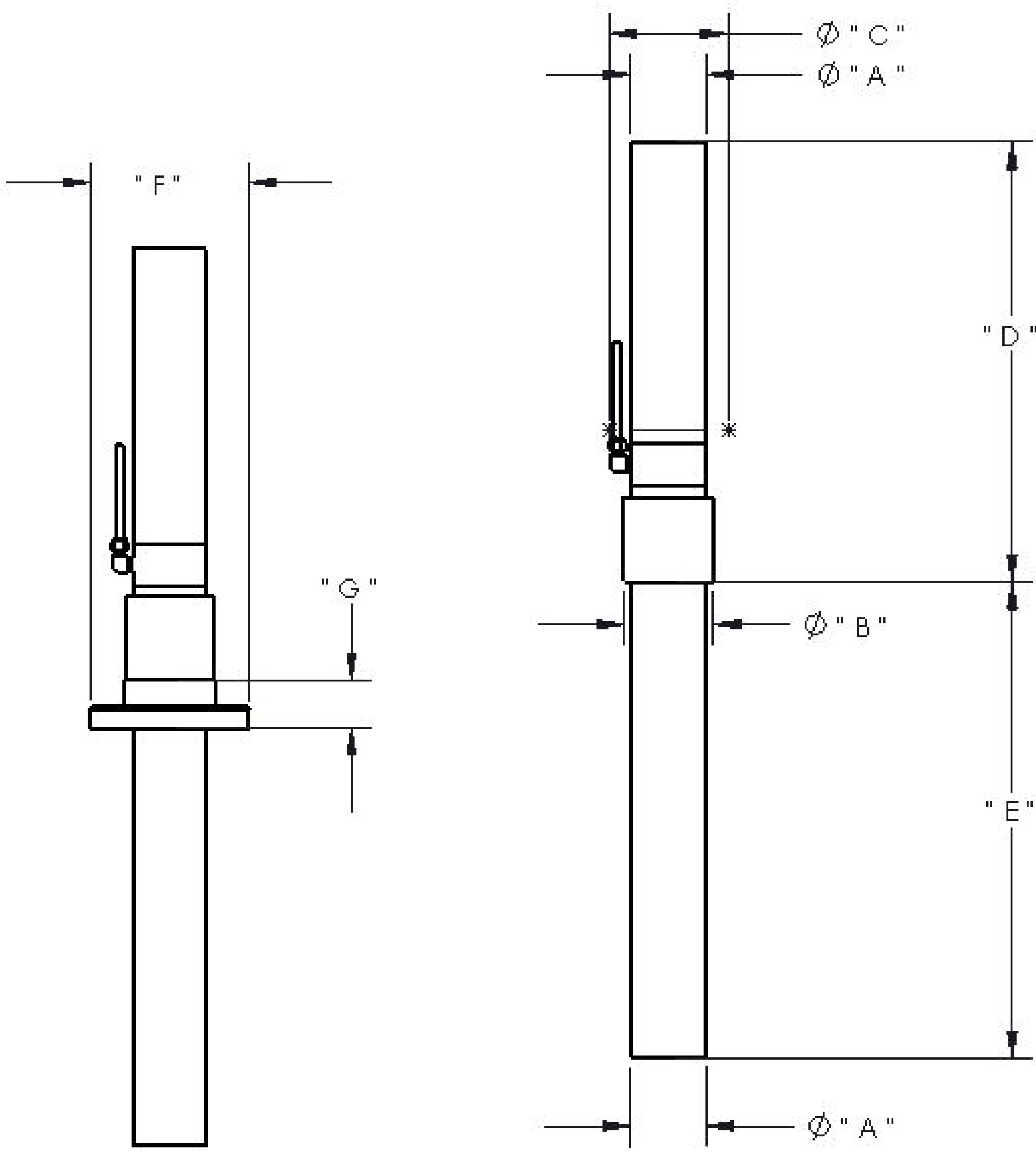

Figure 20 - Head Assemblies Dimensions, Reference Print

# Points	Transducer Range	A	B	C	D	E	F	G
1-2	12.5, 25, 50 mm (0.5, 1, 2 inch)	73 mm (2.88 inch)	88 mm (3.47 inch)	1 point: 122 mm (4.81 inch) 2 points: 125 mm (4.92 inch)	404 mm (15.91 inch)	1480 mm (58.28 inch)	178 mm (7 inch)	57 mm (2.25 inch)
	100 mm (4 inch)				440 mm (17.34) inch			
	150 mm (6 inch)				517 mm (20.34 inch)			
	200 mm (8 inch)				606 mm (23.84 inch)			
	300 mm (12 inch)				758 mm (29.84 inch)			
3-4	12.5, 25, 50 mm (0.5, 1, 2 inch)	89 mm (3.50 inch)	106 mm (4.16 inch)	141 mm (5.54 inch)	407 mm (16.03 inch)	1477 mm (58.13 inch)	191 mm (7.50 inch)	59 mm (2.31 inch)
	100 mm (4 inch)				444 mm (17.47 inch)			
	150 mm (6 inch)				520 mm (20.47 inch)			
	200 mm (8 inch)				608 mm (23.94 inch)			
	300 mm (12 inch)				761 mm (29.97 inch)			
5-6	12.5, 25, 50 mm (0.5, 1, 2 inch)	114 mm (4.50 inch)	135 mm (5.31 inch)	5 points: 176 mm (6.92 inch) 6 points: 183 mm (7.22 inch)	418 mm (16.44 inch)	1467 mm (57.75 inch)	230 mm (9.06 inch)	62 mm (2.44 inch)
	100 mm (4 inch)				454 mm (17.88 inch)			
	150 mm (6 inch)				530 mm (20.88 inch)			
	200 mm (8 inch)				619 mm (24.38 inch)			
	300 mm (12 inch)				771 mm (30.38 inch)			

Table 10 - Head Assemblies Dimensions

APPENDIX B. THERMISTOR TEMPERATURE DERIVATION

Thermistor Type: YSI 44005, Dale #1C3001-B3, Alpha #13A3001-B3
Resistance to Temperature Equation:

$$T=\frac{1}{A+B(LnR)+C(LnR)^3}-273.15\ °C$$

Equation 1 - Resistance to Temperature

Where:

T = Temperature in °C.

LnR = Natural Log of Thermistor Resistance

$A = 1.4051 \times 10^{-3}$

$B = 2.369 \times 10^{-4}$

$C = 1.019 \times 10^{-7}$

Note: Coefficients calculated over the –50 to +150 °C. span.

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	16.60K	-10	2417	+30	525.4	+70	153.2	+110
187.3K	-49	15.72K	-9	2317	31	507.8	71	149.0	111
174.5K	-48	14.90K	-8	2221	32	490.9	72	145.0	112
162.7K	-47	14.12K	-7	2130	33	474.7	73	141.1	113
151.7K	-46	13.39K	-6	2042	34	459.0	74	137.2	114
141.6K	-45	12.70K	-5	1959	35	444.0	75	133.6	115
132.2K	-44	12.05K	-4	1880	36	429.5	76	130.0	116
123.5K	-43	11.44K	-3	1805	37	415.6	77	126.5	117
115.4K	-42	10.86K	-2	1733	38	402.2	78	123.2	118
107.9K	-41	10.31K	-1	1664	39	389.3	79	119.9	119
101.0K	-40	9796	0	1598	40	376.9	80	116.8	120
94.48K	-39	9310	+1	1535	41	364.9	81	113.8	121
88.46K	-38	8851	2	1475	42	353.4	82	110.8	122
82.87K	-37	8417	3	1418	43	342.2	83	107.9	123
77.66K	-36	8006	4	1363	44	331.5	84	105.2	124
72.81K	-35	7618	5	1310	45	321.2	85	102.5	125
68.30K	-34	7252	6	1260	46	311.3	86	99.9	126
64.09K	-33	6905	7	1212	47	301.7	87	97.3	127
60.17K	-32	6576	8	1167	48	292.4	88	94.9	128
56.51K	-31	6265	9	1123	49	283.5	89	92.5	129
53.10K	-30	5971	10	1081	50	274.9	90	90.2	130
49.91K	-29	5692	11	1040	51	266.6	91	87.9	131
46.94K	-28	5427	12	1002	52	258.6	92	85.7	132
44.16K	-27	5177	13	965.0	53	250.9	93	83.6	133
41.56K	-26	4939	14	929.6	54	243.4	94	81.6	134
39.13K	-25	4714	15	895.8	55	236.2	95	79.6	135
36.86K	-24	4500	16	863.3	56	229.3	96	77.6	136
34.73K	-23	4297	17	832.2	57	222.6	97	75.8	137
32.74K	-22	4105	18	802.3	58	216.1	98	73.9	138
30.87K	-21	3922	19	773.7	59	209.8	99	72.2	139
29.13K	-20	3748	20	746.3	60	203.8	100	70.4	140
27.49K	-19	3583	21	719.9	61	197.9	101	68.8	141
25.95K	-18	3426	22	694.7	62	192.2	102	67.1	142
24.51K	-17	3277	23	670.4	63	186.8	103	65.5	143
23.16K	-16	3135	24	647.1	64	181.5	104	64.0	144
21.89K	-15	**3000**	**25**	624.7	65	176.4	105	62.5	145
20.70K	-14	2872	26	603.3	66	171.4	106	61.1	146
19.58K	-13	2750	27	582.6	67	166.7	107	59.6	147
18.52K	-12	2633	28	562.8	68	162.0	108	58.3	148
17.53K	-11	2523	29	543.7	69	157.6	109	56.8	149
								55.6	150

Table 11 - Thermistor Resistance versus Temperature

APPENDIX C. WIRING CHARTS FOR VIBRATING WIRE TRANSDUCERS

C.1 Single Transducer Wiring Chart

Internal Wiring	GEOKON Cable #02-205V6 (Blue)	Function / Description
Red	Red	Gauge 1+
Black	Black	Gauge 1-
Red	White	Thermistor
Black	Green	Thermistor
N/C	Shield (1)	N/A

Table 12 - Wiring for One Transducer

C.2 Two Transducer Wiring Chart

Internal Wiring	GEOKON Cable #04-375V9 (Violet CAB-504)	Function / Description
Red	Red	Gauge 1+
Black	Black of Red	Gauge 1-
Red	White	Gauge 2+
Black	Black of White	Gauge 2-
Blue	Blue	Thermistor
Black of Blue	Black of Blue	Thermistor
N/C	Shields (4)	Ground

Table 13 - Wiring for Two Transducers

C.3 Three Transducers Wiring Chart

Internal Wiring	GEOKON Cable #04-375V9 (Violet)	Function / Description
Red	Red	Gauge 1+
Black	Black of Red	Gauge 1-
Red	White	Gauge 2+
Black	Black of White	Gauge 2-
Red	Green	Gauge 3+
Black	Black of Green	Gauge 3-
N/C	Blue	Thermistor
N/C	Black of Blue	Thermistor
N/C	Shields (5)	Ground

Table 14 - Wiring for Three Transducers

C.4 Four Transducers Wiring Chart

Internal Wiring	GEOKON Cable #05-375V12 (Tan)	Function / Description
Red	Red	Gauge 1+
Black	Black of Red	Gauge 1-
Red	White	Gauge 2+
Black	Black of White	Gauge 2-
Red	Green	Gauge 3+
Black	Black of Green	Gauge 3-
Red	Blue	Gauge 4+
Black	Black of Blue	Gauge 4-
N/C	Yellow	Thermistor
N/C	Black of Yellow	Thermistor
N/C	Shields (6)	Ground

Table 15 - Wiring for Four Transducers

C.5 Five Transducers Wiring Chart

Internal Wiring	GEOKON Cable #06-500V7 (Orange)	Function / Description
Red	Red	Gauge 1+
Black	Black of Red	Gauge 1-
Red	White	Gauge 2+
Black	Black of White	Gauge 2-
Red	Green	Gauge 3+
Black	Black of Green	Gauge 3-
Red	Blue	Gauge 4+
Black	Black of Blue	Gauge 4-
Red	Yellow	Gauge 5+
Black	Black of Yellow	Gauge 5-
Red	Brown	Thermistor
Black	Black of Brown	Thermistor
N/C	Shields (7)	Ground

Table 16 - Wiring for Five Transducers

C.6 Six Transducers Wiring Chart

Internal Wiring	GEOKON Cable #012-625V5 (Brown CAB-507)	Function / Description
Red	Red	Gauge 1+
Black	Black of Red	Gauge 1-
Red	White	Gauge 2+
Black	Black of White	Gauge 2-
Red	Green	Gauge 3+
Black	Black of Green	Gauge 3-
Red	Blue	Gauge 4+
Black	Black of Blue	Gauge 4-
Red	Yellow	Gauge 5+
Black	Black of Yellow	Gauge 5-
Red	Brown	Gauge 6+
Black	Black of Brown	Gauge 6-
White	White	Thermistor
Red of White	Red of White	Thermistor
N/C	Shields (8)	Ground

Table 16 - Wiring for six Transducers

APPENDIX D. SWAGELOK TUBE FITTING INSTRUCTIONS

These instructions apply to one inch (25 mm) and smaller fittings.

D.1 Installation

1) Fully insert the tube into the fitting until it bumps against the shoulder.

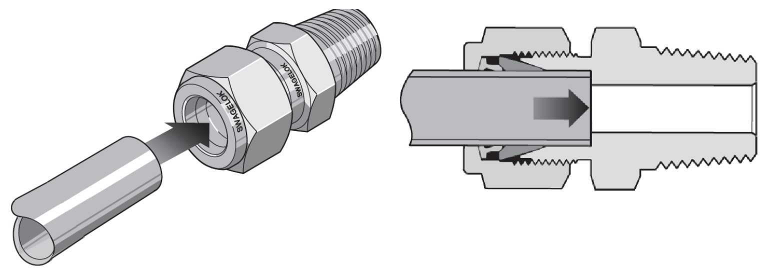

Figure 21 - Tube Insertion

2) Rotate the nut until it is finger tight. (For high-pressure applications as well as high-safety-factor systems, further tighten the nut until the tube will not turn by hand or move axially in the fitting.)

3) Mark the nut at the six o'clock position.

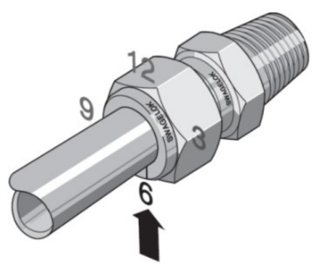

Figure 22 - Make a Mark at Six O'clock

4) While holding the fitting body steady, tighten the nut one and one quarter turns, until the mark is at the nine o'clock position.

   Note: For 1/16-inch, 1/8-inch, 3/16-inch, and 2, 3, and 4 mm fittings, tighten the nut three-quarters of a turn until the mark is at the three o'clock position.)

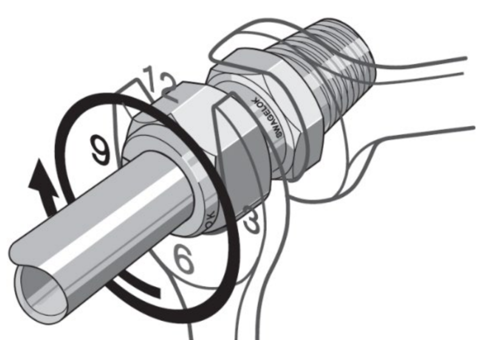

Figure 23 - Tighten One and One-Quarter Turns

D.2 Reassembly Instructions

Swagelok tube fittings may be disassembled and reassembled many times.

<u>Warning!</u> Always depressurize the system before disassembling a Swagelok tube fitting.

1) Prior to disassembly, mark the tube at the back of the nut, then make a line along the nut and fitting body flats. *These marks will be used during reassembly to ensure the nut is returned to its current position.*

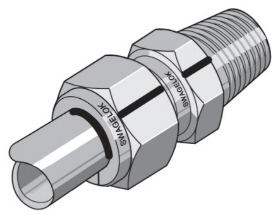

Figure 24 - Marks for Reassembly

2) Disassemble the fitting.

3) Inspect the ferrules for damage and replace if necessary. **If the ferrules are replaced the connector should be treated as a new assembly. Refer to the section above for installation instructions.**

4) Reassemble the fitting by inserting the tube with pre-swaged ferrules into the fitting until the front ferrule seats against the fitting body.

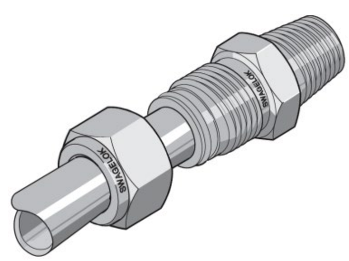

Figure 25 - Ferrules Seated Against Fitting Body

5) While holding the fitting body steady, rotate the nut with a wrench to the previous position as indicated by the marks on the tube and the connector. At this point, there will be a significant increase in resistance.

6) Tighten the nut slightly.

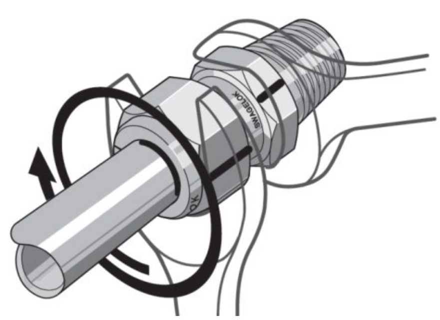

Figure 26 - Tighten Nut Slightly

<u>APPENDIX E. GUIDE TO ORDERING EXTENSOMETERS</u>

Ordering Information for 1100 Series Standard Extensometer. See Section 1.2, System Components for a detailed description of each component.

1) Extensometer Head Assembly:

Specify Part Number from Options A, B & C. 1100 - ______ - **B** - **C**
Example: 1100 - **3** 100 SS

Letter	Meaning	Options
A	Number of Measurement Points	1, 2, 3, 4, 5 & 6
B	Transducer Range (mm)	12.5, 25, 50, 100, 150, 200 & 300
C	Rod Type	SS (Stainless Steel) or FIB (Fiberglass)

2) Anchor Type:

- ☐ Groutable P/N 1100-Groutable: Specify rod type:
  - ☐ Stainless Steel
  - ☐ Fiberglass
- ☐ Hydraulic Bladder Anchor P/N 1100-BLADDER: Hydraulic bladder anchor with check valve. Specify measurement points and rod type.
- ☐ Hydraulic Single Borros Anchor P/N 1100-S-BORROS: Hydraulic Borros type anchor, single action. Specify rod type.
- ☐ Hydraulic Double Borros Anchor 1100-D-BORROS: Hydraulic Borros type anchor, double action. Specify rod type.

3) Anchor depths*: from installation surface to tip of anchor for each anchor.
Anchor #1 ______ Anchor #2 ______ Anchor #3 ______
Anchor #4 ______ Anchor #5 ______ Anchor #6 ______
**See Section 2.3* Anchor Spacing *for information on anchor spacing*

Optional Accessories:

Grout Tube:

- ☐ P/N TUB-104-E (feet) or P/N TUB-104-M (metric) 19 mm (0.75 inch) O.D. Grout Tube. Indicate Length: _________

Installation Tools:

- ☐ P/N 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).
  Measurement points ______
  Transducer range ______

- ☐ P/N 1100-TOOLKIT Set of Installation Tools.

☐ P/N 1100-RECESSED-TOOLS Additional tools required for recessed installations.

Grouting Tools:

☐ P/N 1100-GROUT-DOWN: Set of grouting accessories for inclined downwards installations.
☐ P/N 1100-GROUT-UP: Set of grouting accessories for overhead/upward installations. **Note:** One set may be required per overhead extensometer. Hydraulic pump with quick connect for inflating hydraulic anchors.

Hydraulic Pump and Hose with Quick Connect:

☐ 1100-PUMP: Hydraulic pump with quick connect for inflating hydraulic anchors

Standpipe:

☐ 1100-#(pts 1-2)-COUPLING: PVC standpipe, 2.5 ft (0.75 m) long, with coupling.
☐ 1100-#(pts 3-4)-COUPLING: PVC standpipe, 2.5' (0.75 m) long, with coupling.
☐ 1100-#(pts 5-6)-COUPLING: PVC standpipe, 2.5' (0.75 m) long, with coupling.

☐ 1100-#(pts 1-2)-FLANGE: PVC standpipe, 2.5' (0.75 m) long, with flange.
☐ 1100-#(pts 3-4)-FLANGE: PVC standpipe, 2.5' (0.75 m) long, with flange.
☐ 1100-#(pts 5-6)-FLANGE: PVC standpipe, 2.5' (0.75 m) long, with flange.

Readout Instrument

☐ Many different options. Consult with GEOKON's Sales Department for best option to fit your needs

Additional Considerations:

Location of extensometer head assembly. See Section 1, Figure 1.
(Location is used for calculating correct connecting rod, PVC pipe or tubing lengths)

☐ Protruding
☐ Recessed in borehole.
Indicate depth from surface to top of protective cap: __________
☐ Recessed in over core
Indicate depth from surface to top of protective cap: __________
Indicate over core depth from grade: __________
☐ Flange recessed in over core
Indicate depth from surface to top of protective cap: __________
Indicate over core depth from grade: __________

Note: See Section 2 INSTALLATION CONSIDERATIONS for suggested minimum depths and diameters of overcores

Grouting: Will the borehole be grouted?

- ☐ Yes
- ☐ No

General Information:

6 mm (1/4 inch) Rod: Standard rod length is 3 m (10 feet). Optional rod lengths 1.5 m (5 ft.) Considering site conditions and shipping method.

6 mm (1/4 inch) PVC Pipe: Standard PVC pipe length is 3 m (10 ft.). Optional rod lengths 1.5 m (5 ft.)
Considering site conditions and shipping method