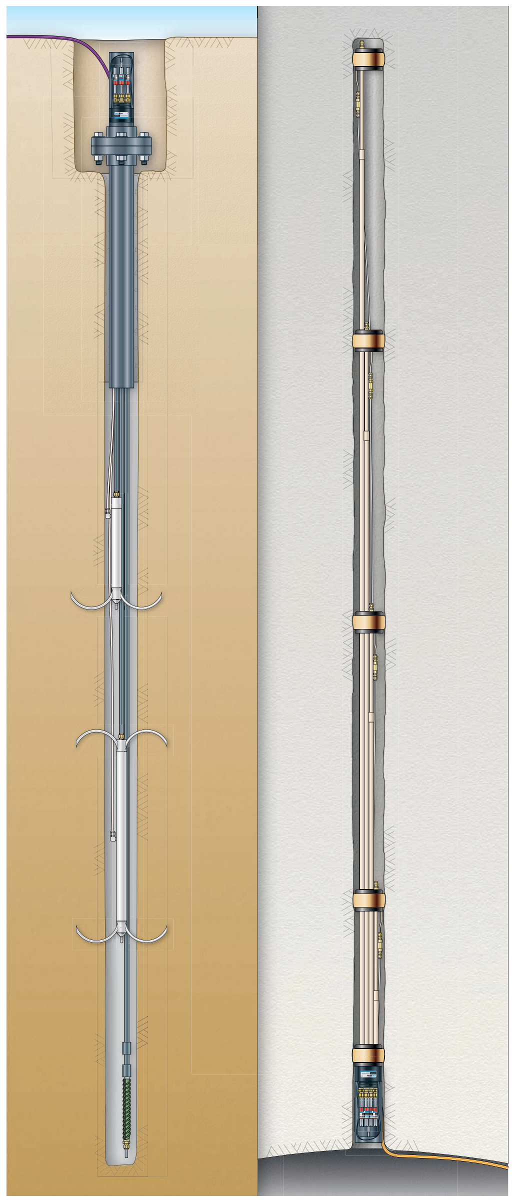
Model 1100

Borehole Extensometer

Instruction Manual



GEOKON®

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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 static 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. A custom DC-DC linear variable differential transformer (LVDT) option is also available.

The measurement from the top of the connecting rod relative to the anchor reveals the magnitude of movement and also narrows down the identification of zones of movement.

To ease installation, the extensometer should be pre-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).

2. SYSTEM COMPONENTS

The four basic components of the extensometer are the head assembly, vibrating wire displacement transducers (contained within the head assembly), connecting rod/tubing, and the borehole anchors. Each of these components are described in the sections that follow.

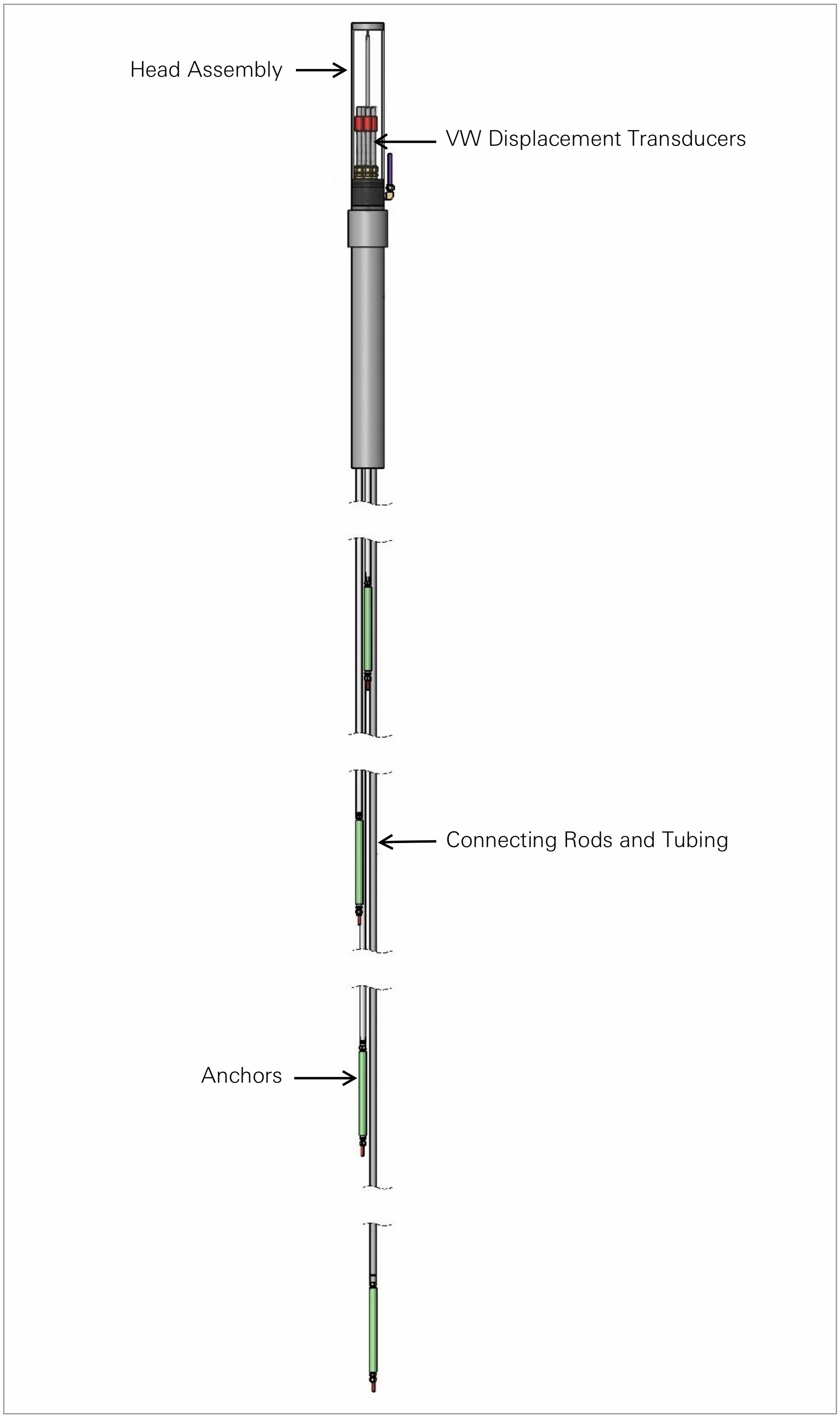

FIGURE 1: *Four Main Components of the Extensometer*

2.1 HEAD ASSEMBLY

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

- Protective cover
- Transducer housing
- Tube mount
- Side-exit cable (custom top exit available)
- PVC coupling (or flange)
- PVC standpipe.

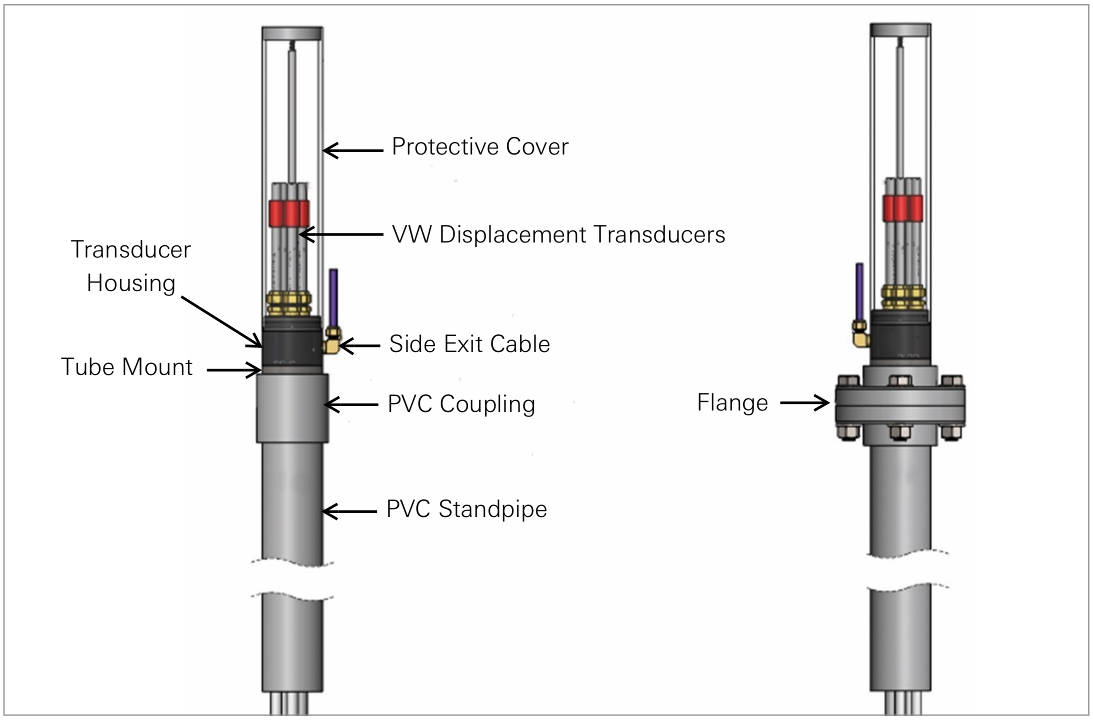

***FIGURE 2:** Main Components of the Head Assembly*

Head assembly sizes vary and are dependent upon the quantity and range of VW displacement transducers. (See Appendix A, Section A.4 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.

2.1.1 COUPLING, STANDPIPE, AND FLANGE

The standpipe is cemented into the borehole and is connected to the tube mount with either a PVC coupling or flange. The coupling works well in confined areas, while the flange option provides extra stability and grip when cemented into the surrounding area.

Note: If using a flange, securing only the bottom half in concrete offers an additional advantage where the head portion of the assembly can be removed (after disconnecting the transducers from the connecting rods) and reused in other monitoring projects. The remaining components of the extensometer assembly will be irretrievable and will need to be purchased for any subsequent projects.

Where the soil/surrounding area around the top of the borehole is stable and no hollow core auger or removable casing is used, the standpipe (with tubemount coupling or flange attached) is cemented into the ground and the extensometer is lowered into it.

If the soil/surrounding area around the top of the borehole is unstable or a hollow core auger or removable casing is used, then the standpipe (with tubemount coupling or flange attached) is slid up the assembled rod and tube column and glued to the tube mount prior to lowering the extensometer into the borehole.

In upward installations, a custom bladder anchor can replace the tube mount and standpipe.

2.2 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 that 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) and 300 mm (12 inch).

2.3 CONNECTING RODS

Connecting rods connect the borehole anchors to the displacement transducers located in the head assembly. The following types of connecting rods are available.

2.3.1 STAINLESS STEEL RODS

The rigidity of stainless steel rods makes them ideal for upward installations and boreholes deeper than 30 meters (100 feet). Stainless steel connecting rods are made from 6 mm (1/4 inch) stainless steel rod sections, flush coupled to form a continuous string. They are encased in rigid PVC pipe, which protects them from grout and other debris, thereby ensuring their ability to move freely as they are acted upon by forces along the axis of the instrument. Standard lengths are 1.5 and 3 m (5 and 10 feet) but are available in other lengths if necessary for installation.

2.3.2 FIBERGLASS RODS

The flexibility of fiberglass rods allows the extensometer to be preassembled at the factory, which significantly reduces the installation process. Fiberglass connecting rods are made from continuous length, 6 mm (1/4 inch) fiberglass. The rods are encased in polyethylene tubing for borehole lengths less than 30 meters (100 feet), and nylon tubing for boreholes of greater depths. The tubing protects them from grout and other debris thereby ensuring their ability to move freely as they are acted upon by forces along the axis of the instrument.

Note: Fiberglass rods are typically not recommended for upward installations or boreholes greater than 30 meters (100 feet) because they lack rigidity. They also 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 (< 0.004 inch) is required. Fiberglass rods are more stable thermally and therefore may be a better choice than stainless steel rods in areas where temperatures vary.

2.3.3 GRAPHITE RODS

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

2.3.4 IN-LINE SLIP COUPLINGS

In-line slip couplings are optional and allow for a greater range of motion. These couplings are recommended where there is more than 0.2 percent of the rod length in 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 coupling may also be considered where separation of the pipe or tube column under significant extension would be undesirable. Without this range of motion, there might be substantial bending or breaking of the PVC tubing or coiling of the fiberglass rod column, which would introduce errors in the measured movement.

In-line slip couplings are designed to attach to individual rod columns. They can be used with stainless steel or fiberglass connecting rods and come with a 10 or 30 cm (4 or 12 inch) range of motion. Multiple units in a single column can be implemented if required.

Slip couplings can be set anywhere within their range and are shipped with dissolvable tape to wrap around the slip location to temporarily hold it until the connecting rods can be locked into place. They are usually installed 1.5-3 meters (5-10 feet) below the head assembly but can be placed anywhere along the rod column.

Note: For Fiberglass rods, the standard location to install a slip coupling is on the fiberglass rod column 1.5-3 meters (5-10 feet) from the head assembly. Installing a slip coupling in a non-standard location along the column may be difficult. Specify at time of order or consult GEOKON for assistance.

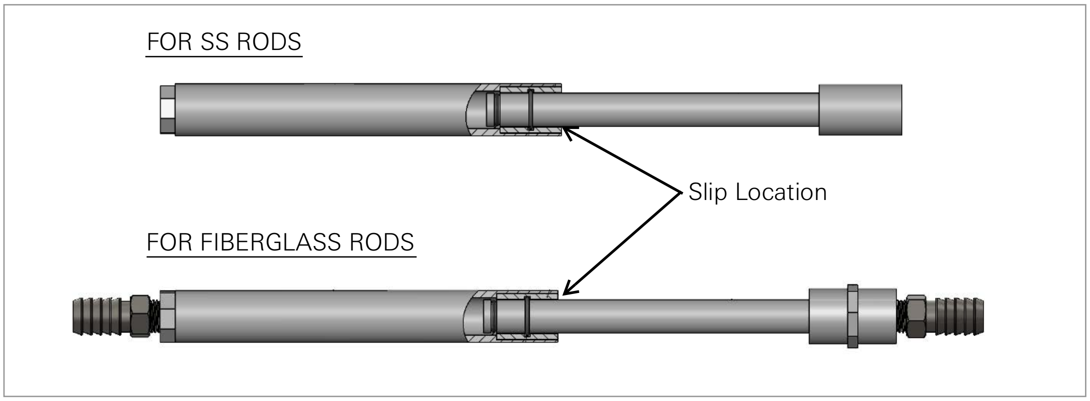

FIGURE 3: *In-Line Slip Couplings*

2.4 BOREHOLE ANCHORS

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

2.4.1 GROUTABLE ANCHOR

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.

There is a through-hole in the anchor where the connecting rod is inserted and then attached to a Swagelok connector on the bottom side. A PVC adapter or barb connector is used to secure the outer protective tubing.

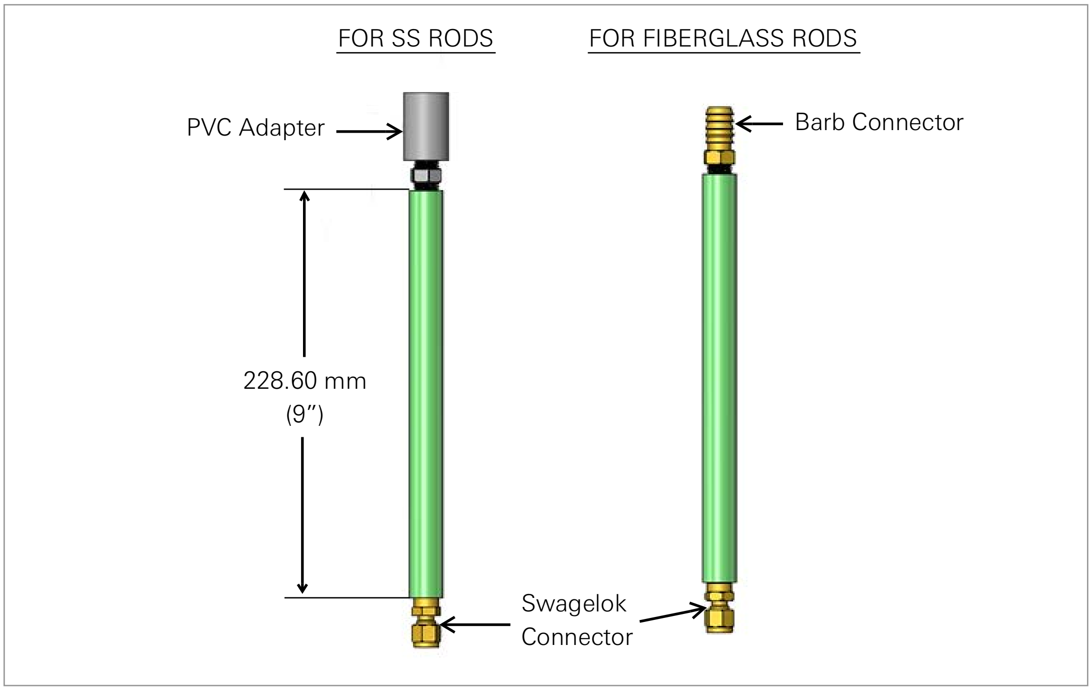

FIGURE 4: *Groutable Anchors*

2.4.2 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 makes them particularly useful in boreholes that are difficult to grout, such as upward oriented or fractured boreholes.

The anchor is comprised of 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.

Bladder anchors are custom sized for each borehole and accommodate up to 30 mm (1.2 inch) of oversize without loss of grip.

There is a through-hole in the anchor where the connecting rod is inserted and then attached to a Swagelok connector on the bottom side. A PVC adapter or barb connector is used to secure the outer protective tubing.

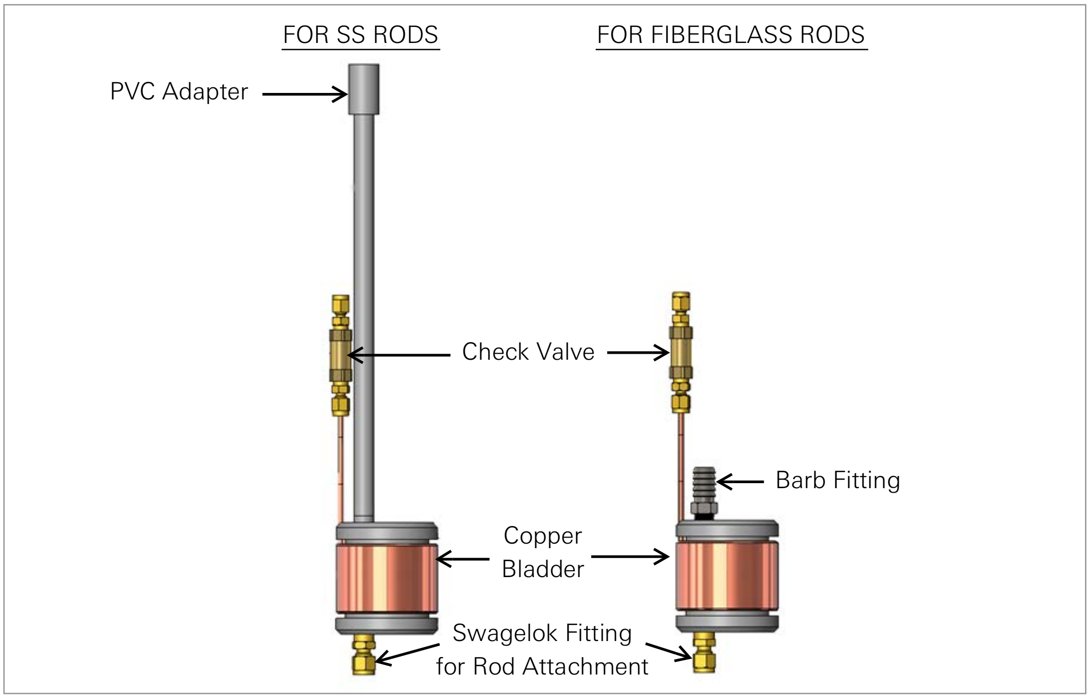

***FIGURE 5:** Hydraulic Bladder Anchors*

2.4.3 SINGLE OR DOUBLE HYDRAULIC BORROS ANCHOR

Hydraulic borros anchors are a type of end-bearing anchor recommended for soft soils. Hydraulically actuated prongs, spaced 120° from one another, penetrate the walls of the borehole, ensuring positive end-bearing anchorage. Single borros anchors (Figure 6) have three prongs located on the bottom end of the anchor; double borros anchors (Figure 7) have an additional three prongs on the top end of the anchor. On both models, the prongs protrude approximately 150 mm (6 inches) from the anchor body when actuated.

Connecting rods are threaded into the top of the anchor. A PVC adapter or barb connector is used to secure the outer protective tubing.

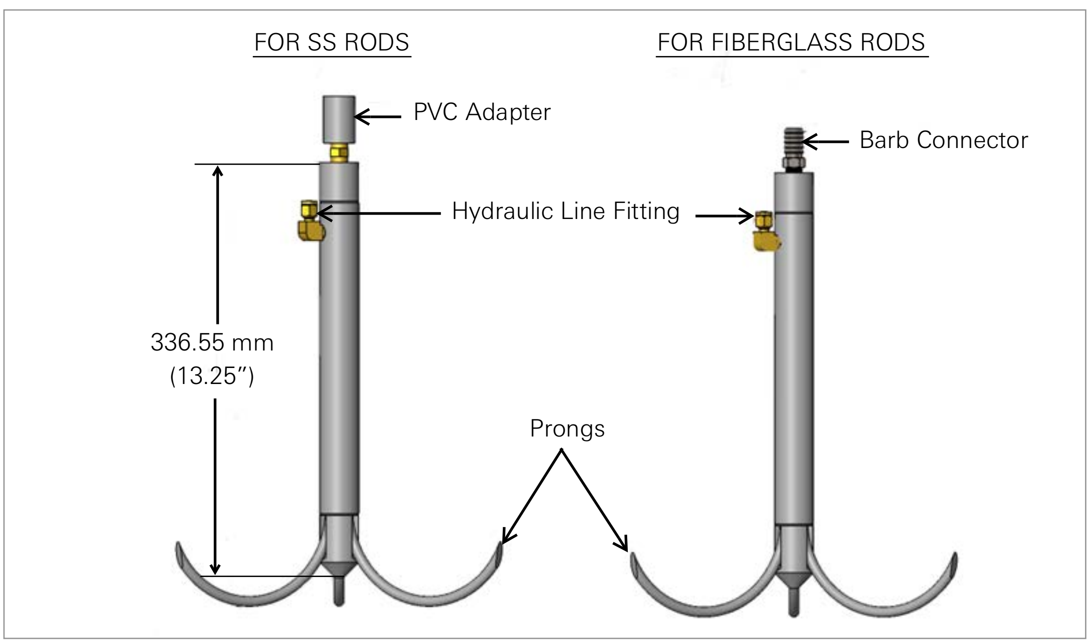

***FIGURE 6:** Single Hydraulic Borros Anchors*

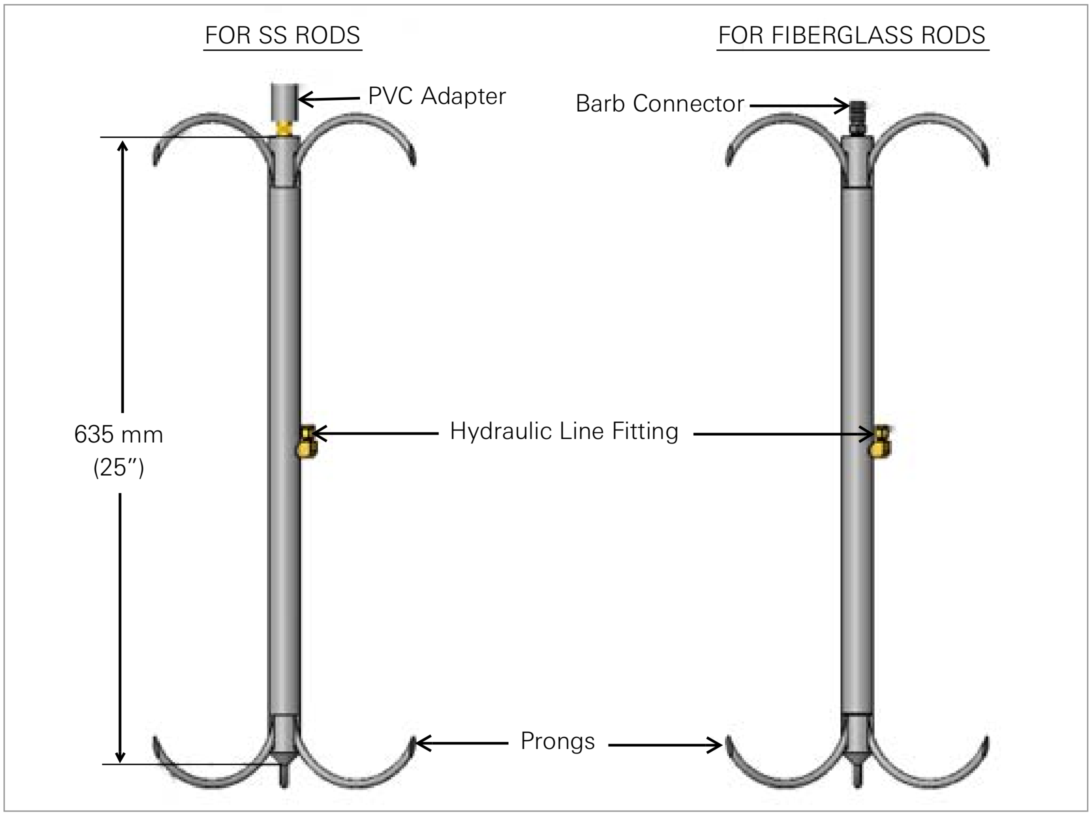

FIGURE 7: *Double Hydraulic Borros Anchors*

3. INSTALLATION CONSIDERATIONS

The installation process for extensometers can take multiple days. It is best to allow grout (if using) to set around the rods and anchors and also allow cement to cure when securing the coupling/flange and tubemount to the surrounding formation before completing the installation. Time should also be allocated for installing protection around the head assembly, as indicated below.

3.1 INSTRUMENT HEAD PROTECTION

The extensometer 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, vandalism, etc.

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

3.2 BOREHOLE DIMENSIONS

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 project. Refer to the following sections to determine borehole diameter and overcore diameter/depth.

3.2.1 EXTENSOMETERS WITHOUT AN OVERCORE

The minimum borehole diameter for extensometers without an overcore 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 8) and Table 2 to determine the minimum borehole diameter for recessed head assemblies (Figure 9).

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. In some cases the standpipe may already be cemented in place, or a standpipe may not be used.

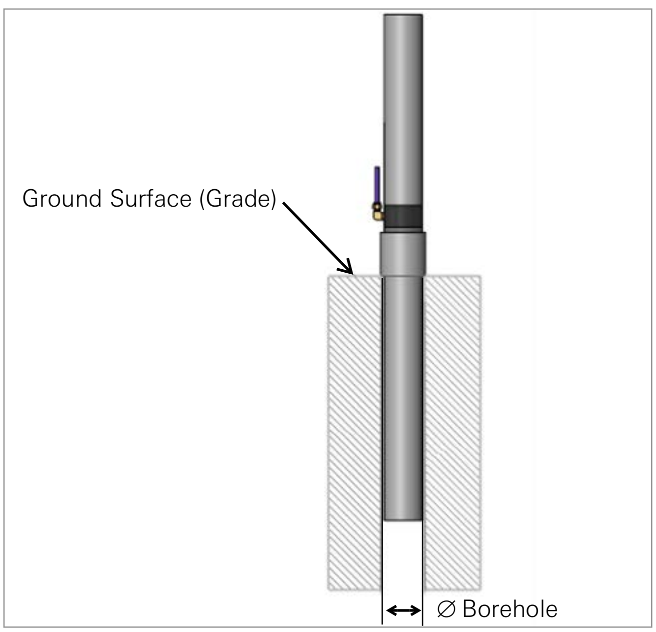

FIGURE 8: *Protruding Above the Borehole*

Number of Points	Minimum 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*

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

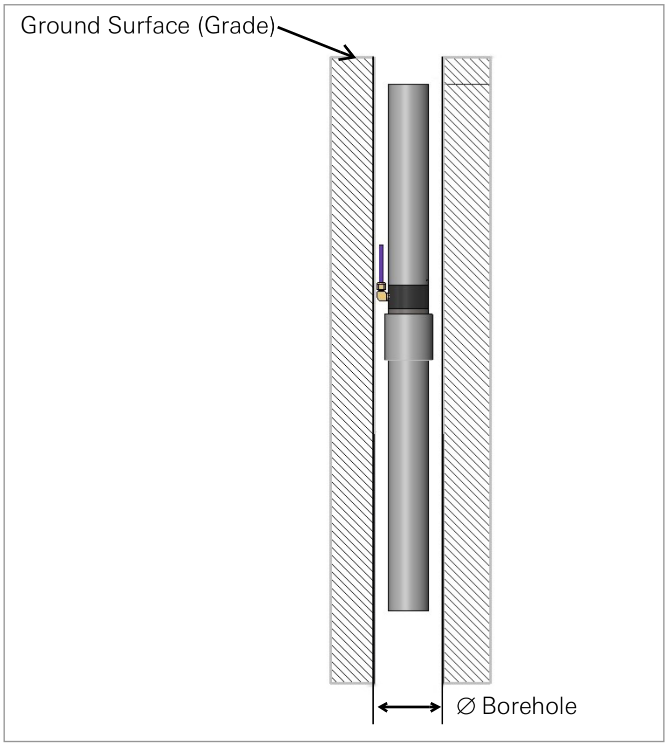

FIGURE 9: Recessed in the Borehole

Number of Points	Minimum 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.

3.2.2 EXTENSOMETERS RECESSED IN AN OVER CORE BOREHOLE

OVERCORE DEPTH

The overcore depth can be determined by adding the head assembly height to the recessed depth (Figure 10). The head assembly height is given in Table 3. The recessed depth is the distance from the ground surface to the top of the protective cap.

Note: For head assemblies with a top cable exit, the recessed depth should be increased a minimum of 77 mm (3 inches).

Number of Points	Transducer Range (VW)	Head Assembly Height NO FLANGE	Head Assembly Height 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 Height*

OVERCORE DIAMETER

The minimum overcore diameter for extensometers protruding above the borehole (Figure 10) is determined by the number of points included in the head assembly and whether a coupling or flange is used. Use Table 4 to find the minimum overcore diameter.

Number of Points	Minimum Overcore Diameter for Coupling	Flange Diameter (Overcore should be larger than the flange diameter)
1-2	125 mm (4.92 inch)	178 mm (7 inch)
3-4	141 mm (5.54 inch)	191 mm (7.50 inch)
5	176 mm (6.92 inch)	230 mm (9.06 inch)
6	184 mm (7.22 inch)	230 mm (9.06 inch)

TABLE 4: *Minimum Overcore Diameter*

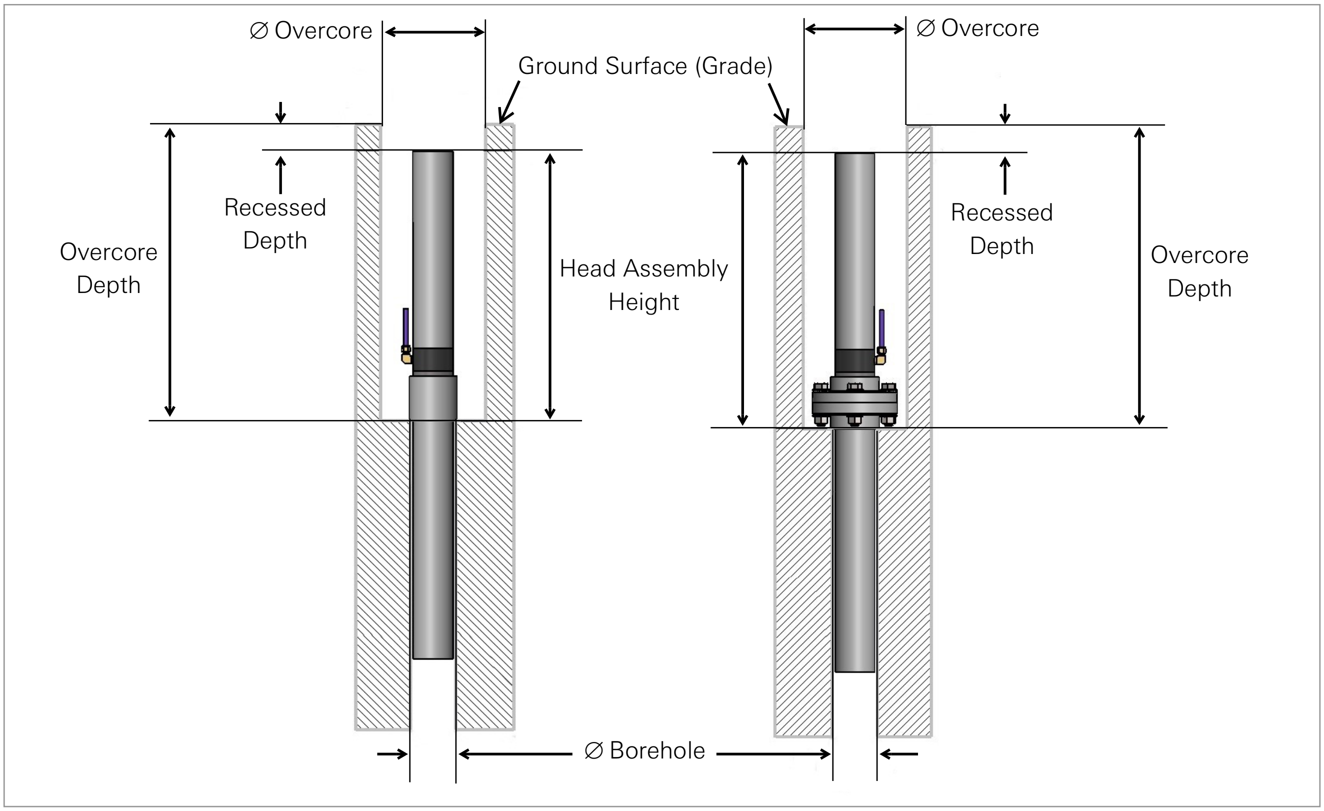

FIGURE 10: *Overcore Depth and Diameter*

3.3 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 stationary reference point for the head and the rest of the anchors. For extensometers installed 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 11.

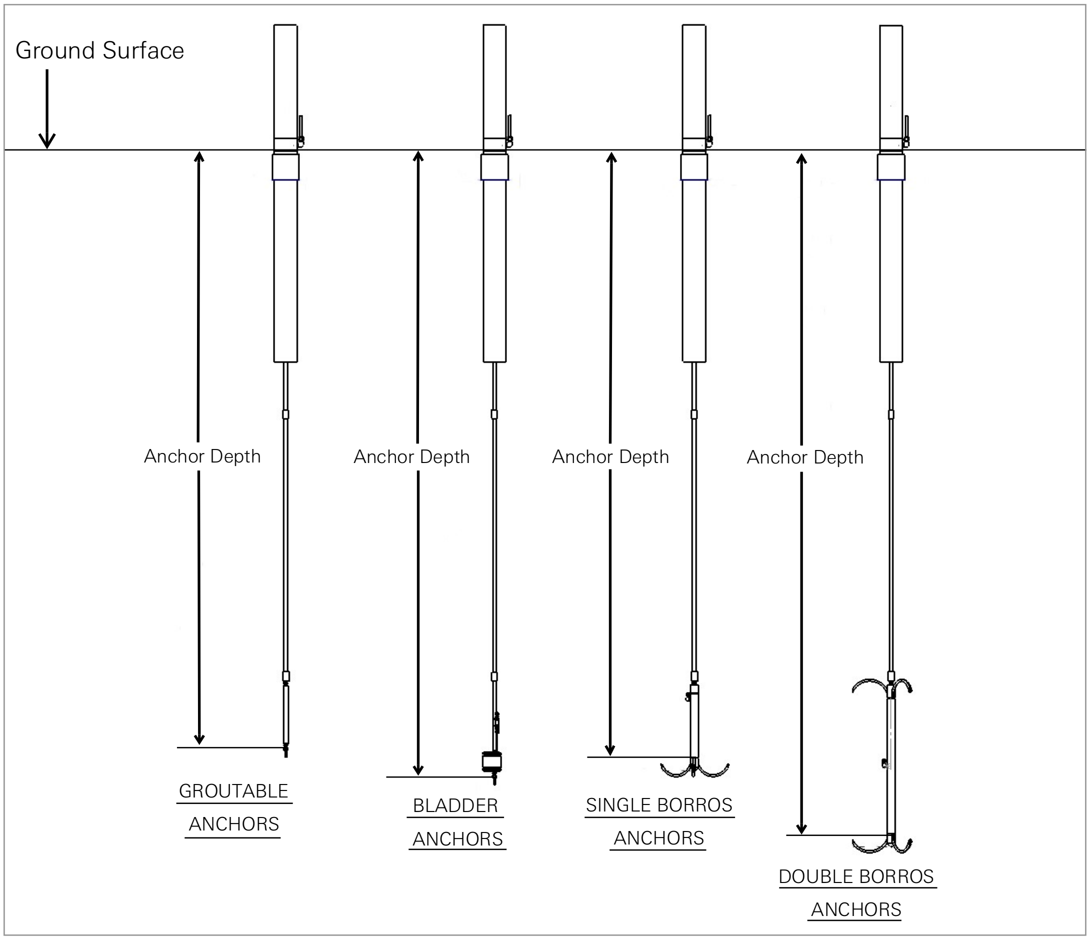

FIGURE 11: *Anchor Depths*

3.4 CABLE INSTALLATION AND SPLICING

The signal cable for an extensometer is typically routed through the head assembly. The head assembly will be installed after the anchors are set (grout has set up or hydraulic anchors activated). This means drilling accessories (casing if used) can be removed and clear of the hole before the head assembly (and signal cable) are attached to the installation.

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, proper 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.

4. INSTALLATION

4.1 PREPARATION

Plan for an installation period spanning two or more days if grouting the borehole.

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 plastic, tarps, or similar. Ideally, the assembly should be done in an area of sufficient length able to accommodate the entire extensometer. The assembly should be laid out in a straight line for accurate measurement of anchor locations relative to the head.

Use caution when unpacking the extensometer to avoid damaging sensitive components. Extensometers are often shipped in multiple boxes. Verify that all components are present and accounted for before beginning the installation.

If using a sacrificial grout pipe, uncoil it carefully and lay it out on the prepared surface. This pipe is tightly wound and holds significant coil memory, laying the pipe out early on will allow it to lose as much coil memory as possible before assembly.

If the soil/surrounding area around the top of the borehole is stable and no hollow core auger or removable casing is used then the standpipe can cemented into the ground prior to assembling the other components. This gives the cement time to cure and reduces delays later on. Refer to Section 4.10 for instructions.

Note: Swagelok fittings are used throughout the installation process and must be tightened correctly. If unfamiliar with Swagelok connectors please refer to Appendix E.

Note: Custom tools are provided with purchase of various tool kits, see Appendix A, Table 17.

4.2 CONNECTING ROD AND ANCHOR ASSEMBLY

4.2.1 STAINLESS STEEL CONNECTING RODS

Assemble the connecting rod lengths on the clean ground surface.

1. Using the provided connecting rod table as a guide (see Appendix B for an example table), lay the connecting rods out in the correct order, with the bottom section nearest to the borehole.
2. Connect the female end of the lowest connecting rod as follows:
   - **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 bottom Swagelok connector. Tighten the Swagelok connector.
   - **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.
3. Install another rod onto the first using two pairs of locking pliers and thread locker. Wipe excess thread locker off the joint to prevent rods from gumming up inside the tubing. **Be careful to not create burrs on the rods when using the locking pliers. If burrs develop, use a fine file to remove and smooth the surface of the rods.**
4. Slide the first section of protective tubing over the rod and glue it into the adapter coupling on top of the anchor using PVC primer and cement.
   - *Primer* is added to the pipe end and the interior of the coupler.
   - PVC *cement* must only be applied to the pipe end, not the interior of the coupler. This reduces potential for pushing cement inside the pipe and onto the rods, inhibiting movement of the rods.
   - If desired, the annular space between the rod and tubing can be filled with grease or other compound for lubrication.

- Allow sufficient time for the cement to harden. (In cold weather, it may be advisable to warm the connector with a propane torch.)

Note: PVC primer and cement must be obtained locally. Restrictions prohibit GEOKON from shipping these materials.

5. If using in-line slip couplings proceed to Section 4.3.
6. Continue to assemble alternating sections of connecting rods and protective tubing (using the supplied couplers) until the appropriate length is achieved.

Important! The end of the protective tubing will need to be trimmed in a later step. Do not assemble a PVC coupling to the very end of the assembled length of protective tubing.

Note: If assembling over a long day where significant temperature changes are expected, the PVC pipe will contract and expand accordingly and could change length.

7. Skip to Section 4.4 for the next step of the installation process.

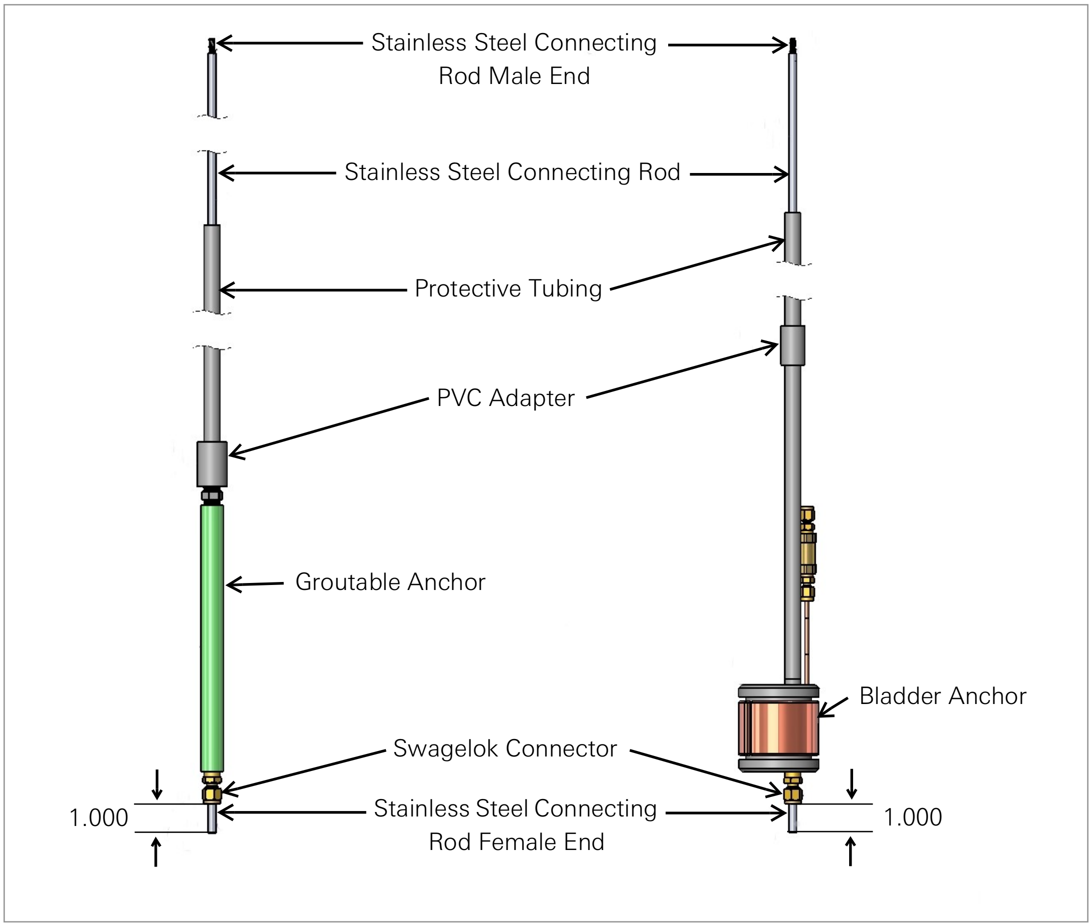

FIGURE 12: *Groutable and Bladder Anchors*

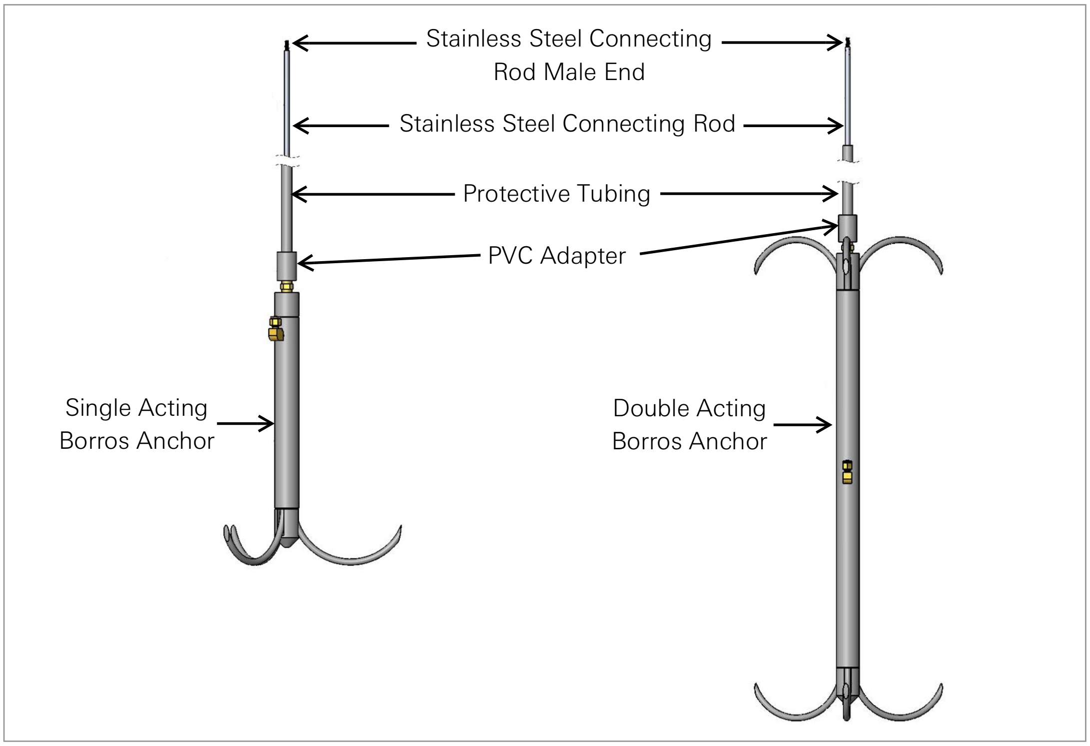

FIGURE 13: Borros Anchors

4.2.2 FIBERGLASS CONNECTING RODS

1. Uncoil the bundle of fiberglass by carefully cutting one tape wrapping at a time, sequentially around the bundle.

Caution! Do not try to cut more than one tape joint at a time. The coiled rod/tubing behaves like a tight spring and can unwind violently.

2. Lay the uncoiled rod assembly out on the prepared surface with the deepest anchor closest to the borehole.
3. Depending on the anchor type, perform the step(s) below.

Groutable or Bladder Anchors:

If using groutable or bladder anchors the fiberglass connecting rods will come with the anchors pre-attached.

Borros Anchors:

a. Pull back the tubing to expose the female threaded end of the inner rod.
b. Using thread locker, screw this end onto the setscrew located in the top of the borros anchor.
c. Pull the tubing down and install snugly over the barb fitting on the anchor. 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 may cause poor connection to the barb fitting.

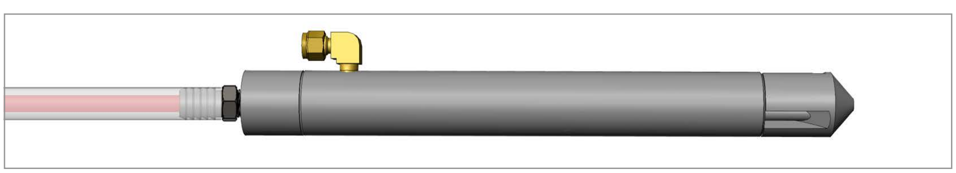

FIGURE 14: Borros Anchor and Fiberglass Connecting Rod/Tubing Assembly

4. If using in-line slip couplings follow instructions in Section 4.3.
5. Proceed to Section 4.4 for the next step of the installation process.

4.3 INSTALLING IN-LINE SLIP COUPLINGS

4.3.1 SLIP COUPLINGS FOR STAINLESS STEEL CONNECTING RODS

1. Continue to assemble alternating sections of connecting rod and protective tubing until there is approximately 3 m (10 feet) remaining to assemble.
2. Assemble **only** the connecting rod to it's full length. The protective tubing must be left 1.5-3 meters (5-10 feet) short from the full assembled length.
3. Slide slip coupling over the rod (coupling end first) and connect to the protective tubing using PVC primer/cement. *Primer* is added to the end of the pipe and the interior of the coupler. PVC *cement* must only be applied to the pipe end, not the interior of the coupler. This reduces potential for pushing cement inside the pipe and onto the rods, inhibiting movement of the rods.
4. Extend or compress the slip coupling to the desired position depending on expected settlement or heave. Wrap supplied dissolvable tape around the slip location.
5. Assemble the remaining length of protective tubing to the slip coupling.

Important! The end of the protective tubing will need to be trimmed in a later step. Do not assemble a PVC coupling to the very end of the assembled length of protective tubing.

Note: If assembling over a long day where significant temperature changes are expected, the PVC pipe will contract and expand accordingly and could change length.

6. Proceed to Section 4.4.

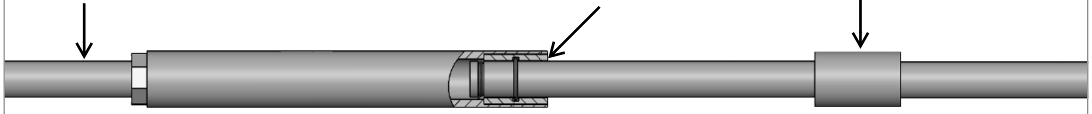

FIGURE 15: *Installed Slip Couping on Stainless Steel Connecting Rods*

4.3.2 SLIP COUPLINGS FOR FIBERGLASS CONNECTING RODS

1. Cut **ONLY THE PROTECTIVE TUBING** 1.5-3 meters (5-10 feet) from the end that will connect to the head assembly. Slide the tubing off of the rod, reserve the cut section.
2. Slide slip coupling over the rod (smaller O.D. tube end first), pull the tubing up and install snugly over the barb fitting (Figure 16). 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 may cause poor connection to the barb fitting.

3. Extend or compress the slip coupling to the desired position depending on expected settlement or heave. Wrap supplied dissolvable tape around the slip location.
4. Slide the reserved cut section over the rod and install onto the other barb fitting in the same manner as Step 2.
5. Proceed to Section 4.4.

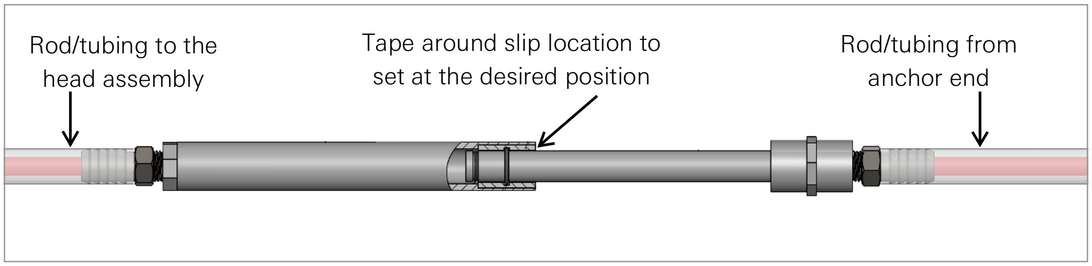

FIGURE 16: *Installed Slip Couping on Fiberglass Connecting Rods*

4.4 CUT BACK LENGTH

The final section of outer tubing extending over each rod needs to be cut before connecting to the guide tubes on the tube mount.

Trim the outer tubing so the rod/rod tip extends beyond it, as indicated in the table below.

	Cut Back Length Based On Transducer Range							
	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: *Cut Back Length*

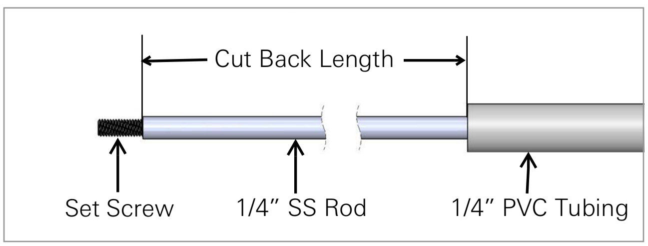

FIGURE 17: *Stainless Steel Cut Back Length*

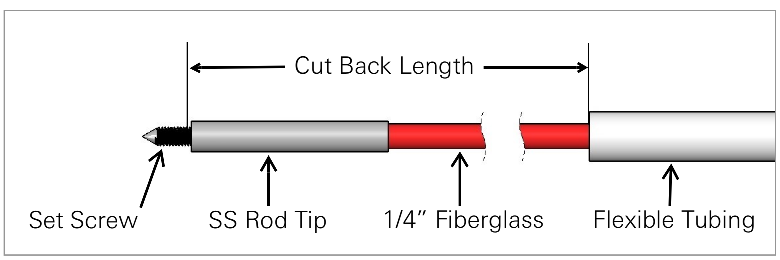

FIGURE 18: *Fiberglass Cut Back Length*

4.5 ATTACHING THE RODS TO THE TUBE MOUNT

Model 1450 Manual

If installing an extensometer with Model 1450 DC-DC LVDT Displacement Transducers, note the installation exceptions outlined in the Model 1450 Instruction Manual before proceeding.

1. Using the supplied Allen wrench, remove the cap screw(s) at the top of the protective cover, then separate the cover from the transducer housing.

Note: You will experience some resistance when removing the protective cap due to the O-ring seal.

2. Remove the cap screws in the transducer housing. Separate the transducer housing from the tube mount.

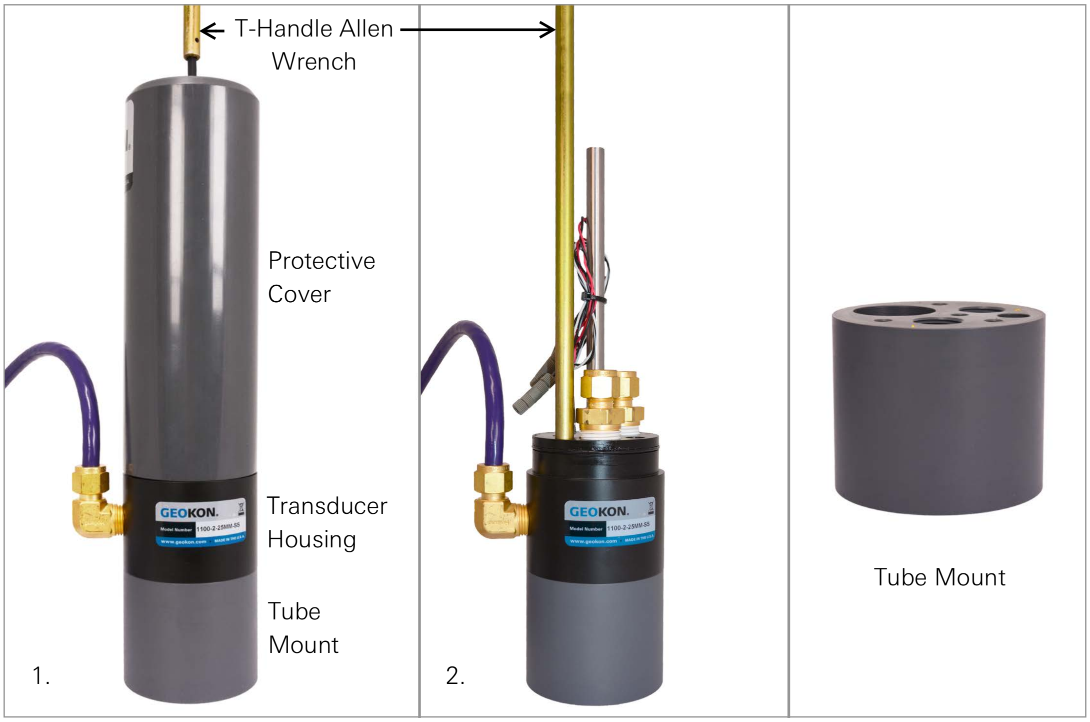

FIGURE 19: *Remove the Protective Cover and Transducer Housing*

3. Replace the protective cover onto the transducer housing (keep all removed cap screws safely stored inside the cover) and place in safe area until needed.
4. Thread the supplied guide tube(s) into the tube mount.

FIGURE 20: *Guide Tubes Installed Onto Tube Mount*

5. Insert the rod tips through the guide tubes. The anchor mounting points on the tube mount are numbered. The shallowest anchor should be attached to mounting point #1. The remaining anchors are attached in order, with the deepest anchor connected to the highest number.

Important! Extensometers with 1, 3, or 5 total points will not use the highest numbered mounting point.

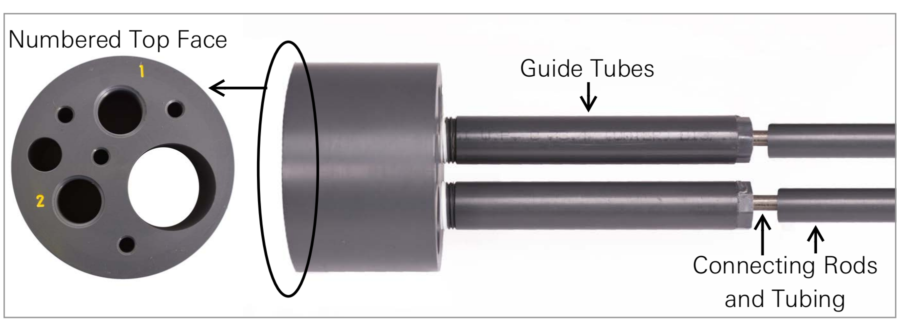

FIGURE 21: *Insert the Rod Tips into the Guide Tubes*

6. Attach the outer tubing to the guide tubes as follows:
   - **For Stainless Steel Connecting Rods:** Attach tubing to guide tubes (Figure 22) using PVC primer/cement, following the same guidelines from Section 4.2.1, Step 4.
   - **For Fiberglass Connecting Rods:** Attach tubing to guide tubes (Figure 22) by pushing the tubing onto the barb fitting snugly. 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 may cause poor connection to the barb fitting.

FIGURE 22: *Outer Tubing Attached to Guide Tubes, Stainless Steel (Top) and Fiberglass (Bottom)*

4.6 ATTACH EXTENSION RODS TO CONNECTING ROD COLUMN

1. Slide the supplied extension rod through the top of the tube mount and tighten it onto the connecting rod column, finger tight only, **do not use thread locker on these threads**. The extension rod is used for alignment purposes only and will be removed later in the process. Repeat with the remaining extension rods.

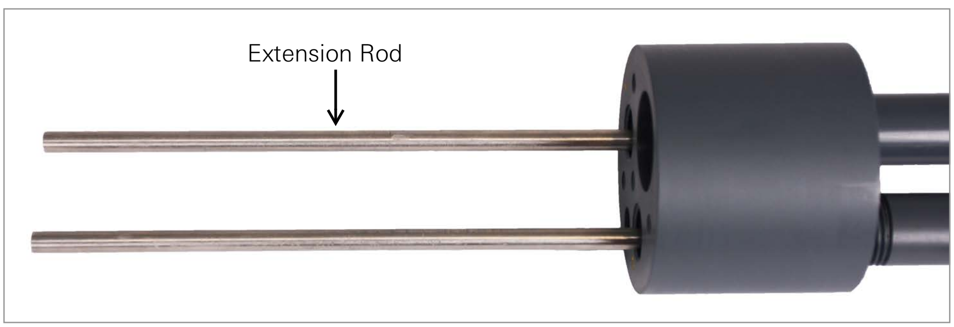

FIGURE 23: *Attach Extension Rods to Internal Rod Column*

2. Slide the supplied 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. Repeat this process for the remaining rod columns.

Warning! Tightening the Swagelok(s) 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.

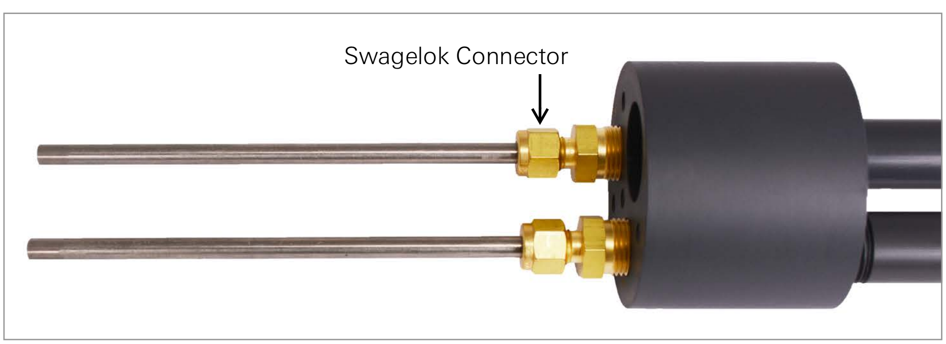

FIGURE 24: *Secure the Extension Rods*

3. Thread the supplied eyebolt(s) into the top of the tube mount. Install the supplied green plugs into the remaining threaded holes to keep debris from getting in the threads.

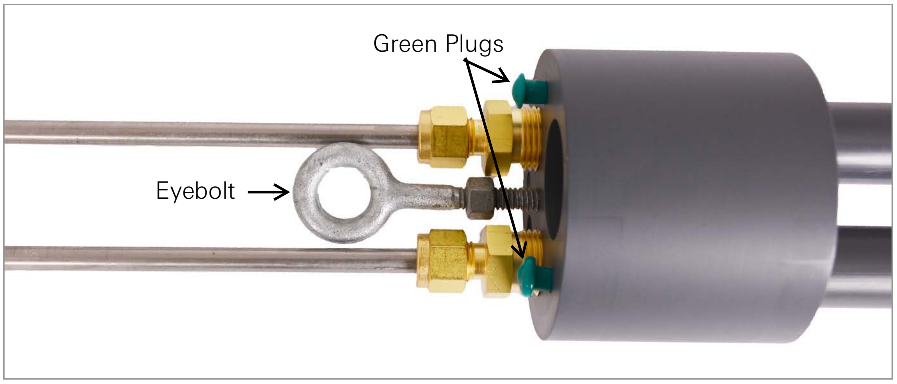

FIGURE 25: *Eyebolt and Plugs Installed*

4.7 HYDRAULIC LINE INSTALLATION (HYDRAULIC BLADDER OR BORROS ANCHORS ONLY)

Connect the hydraulic line to the anchor using the Swagelok connector.

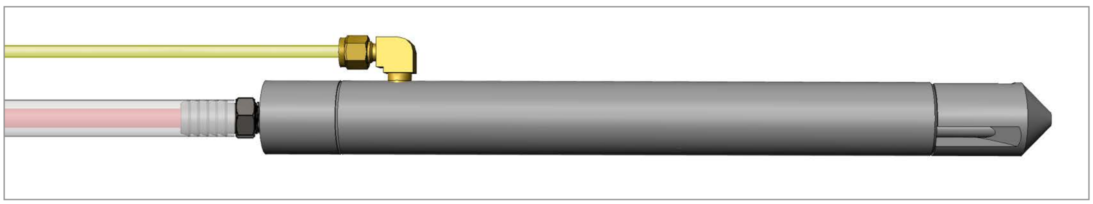

FIGURE 26: *Hydraulic Line Installed on Hydraulic Borros Anchor*

Slide the hydraulic line up through the hydraulic line opening in the tube mount. Leave enough hydraulic line protruding above the tube mount to attach the hydraulic pump. Repeat for the remaining anchors.

Important! Anchors need to be activated in order, from the deepest to the shallowest. For this reason it is very important to label each line with respect to the corresponding anchor.

4.8 SACRIFICIAL GROUT PIPE INSTALLATION (IF APPLICABLE)

Slide the sacrificial grout pipe through the grout pipe opening (typically 28.6 mm or 1.125" in diameter) in the tube mount until it extends approximately 150 mm (6 inches) beyond the **deepest anchor**. Attach the grout pipe (with tape) to the connecting tubing of the deepest anchor at roughly 3 m (10 feet) intervals. (Do not tape to the other anchor/tubing columns.) Using a hacksaw, cut a few small openings in the grout pipe at 0.25 m (0.82 feet) 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.

Note: For upward installations the grout tube needs to extend just beyond the standpipe. A vent line running the length of the borehole must also be installed.

4.9 BUNDLE THE RODS AND ANCHORS TOGETHER

If desired, use nylon filament tape (provided with purchase of Model 1100-TOOLKIT) to **loosely** bundle the rod and anchor assemblies together. Start at the head assembly and work downward, applying tape every 2 m (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.

4.10 STANDPIPE INSTALLATION

1. **If using a flange:** Snugly bolt the two flange ends together.

FIGURE 27: *Assembled Flange*

2. Glue the coupling or flange to the standpipe using PVC primer/cement. If using a flange, orient the threaded ends of the bolts toward the standpipe.

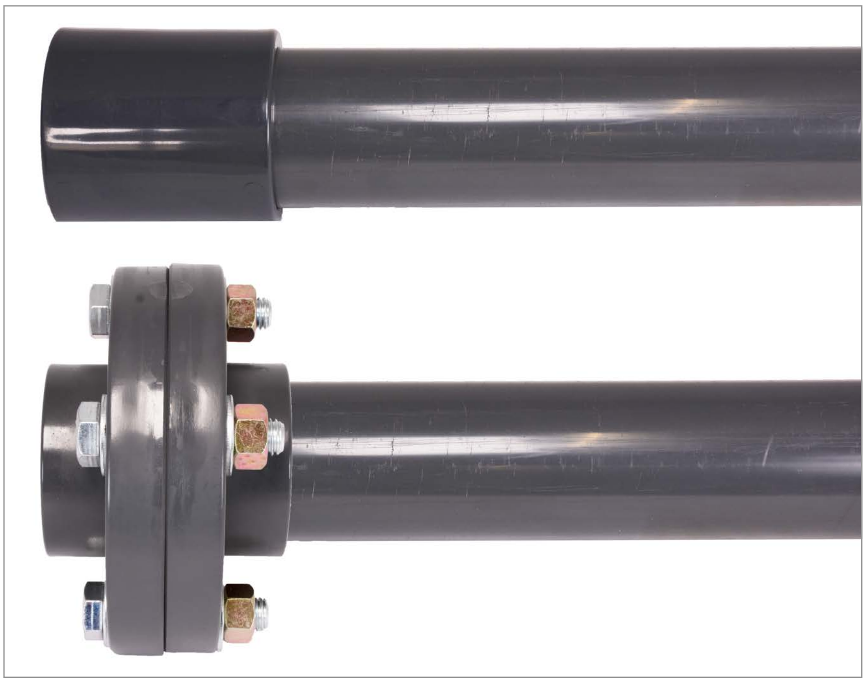

FIGURE 28: *Standpipe and Coupling Assembly (Top) or Flange Assembly (Bottom)*

Standpipe installation will vary depending on the stability of the installation site and whether a hollow core auger or removable casing is being used. Choose the option best suited for the installation/job site:

4.10.1 OPTION ONE

This option is recommended if the soil/surrounding area around the top of the borehole is stable and no hollow core auger or removable casing is being used:

a. Apply quick setting (hydraulic) cement on the outside of the standpipe and insert it into the borehole to the required depth/elevation.

b. Hold the standpipe in place until the cement hardens (Figure 29). This can be accomplished using wooden wedges, sackcloth soaked in quick-setting cement, or other similar methods as required.

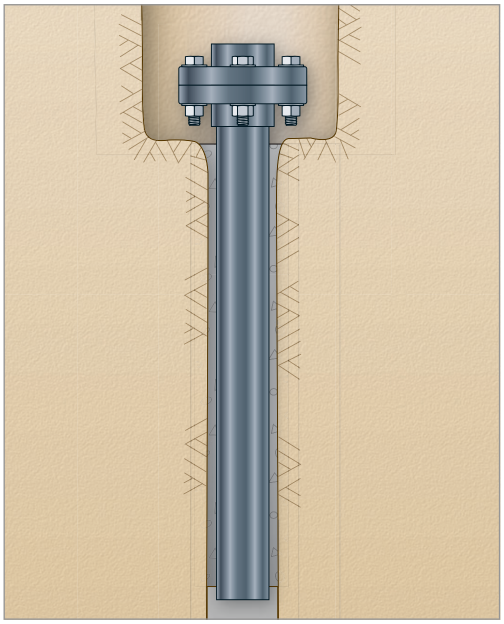

FIGURE 29: *Standpipe/Coupling Installed in Borehole*

4.10.2 OPTION TWO

This option is recommended if the soil/surrounding area around the top of the borehole is loose or otherwise unstable and/or if a hollow core auger or removable casing is being used.

a. Slide the standpipe, **coupling/flange end first**, onto the assembly starting at the bottom of the installed anchors. Also slide over the sacrificial grout tube if applicable.

b. Slide standpipe all the way up to the tube mount, glue together using PVC primer/cement (Figure 31).

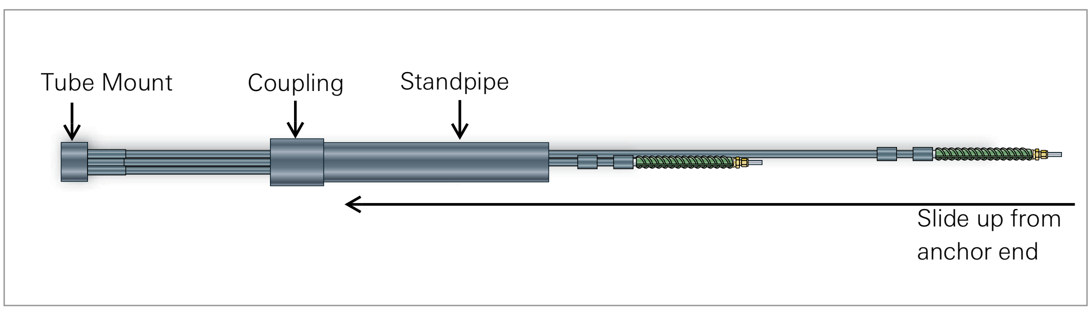

FIGURE 30: *Slide Standpipe/Coupling Up the Assembly From the Bottom Anchors*

FIGURE 31: *Standpipe/Coupling Installed on Head Assembly*

4.11 LIFTING THE EXTENSOMETER ASSEMBLY INTO THE BOREHOLE

1. Connect enough customer supplied rope or cable to the eye bolt(s) located in the top of the tube mount. This will facilitate insertion and suspension of the extensometer assembly into the borehole.
2. Carefully move the extensometer assembly toward the borehole, create a large arc with the rods/tubes of at least 3 meters (10 feet), and then insert the assembly into the borehole. (Fiberglass connecting rods can handle a tighter bend radius.)

Note: For upward installations, it may be possible to push a short extensometer system with stainless steel connecting rods into the borehole with no additional tools. Long systems or extensometers with fiberglass connecting rods will likely require additional tools to overcome friction with the borehole walls. A pull-in anchor wedged into the back of the borehole can be used to facilitate installation.

3. If the standpipe has been cemented into the borehole separately of the tube mount, apply PVC primer/cement to the bottom half of the tube mount and the coupling/flange of the standpipe.
4. Lower the extensometer until the top of the tube mount is at the correct elevation.
5. Keep the extensometer suspended. If securing to a standpipe that is already cemented into the borehole, the extensometer only needs to be suspended until the PVC primer/cement between the tube mount and coupling/flange has cured.
6. **For upward installations:** The mouth of the borehole must be sealed (dry pack concrete can be used) and cured before grouting.

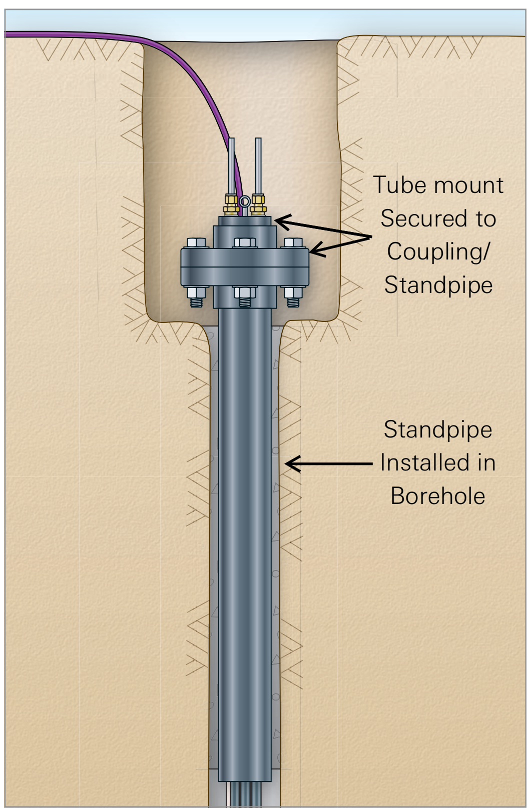

FIGURE 32: *Extensometer Assembly Secured with Standpipe, Recessed Installation Shown*

4.12 SETTING ANCHORS

4.12.1 GROUTABLE ANCHORS

A cement-bentonite grout mix is suggested for backfilling a 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 should be tremie-placed from the bottom of the borehole.

Grout mixtures should be determined and adjusted to be of strength parameters less than the surrounding soil. Throughout the depth of a borehole, the surrounding soil will typically not be all of the same strength and permeability. However, the use of several types of grout mixes within the same borehole may not be cost effective and practical. Unless it is necessary to do so, identify one type of grout mix that would be applicable to the entire length of the borehole.

The table below shows two possible 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, similar to very stiff/hard clay. The modulus is about 10,000 psi.		The 28–day strength of this mix is about 4 psi, similar to very soft clay.	

TABLE 6: *Cement / Bentonite / Water Ratios*

Perform the following steps to mix the cement-bentonite grout:

1. 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.

   Tip: The most effective way of mixing the two substances is to use a drill rig pump to circulate the mix in a 50 to 200 gallon barrel or tub.

2. While mixing, 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 five to 10 minutes to allow the grout to thicken.

3. Add more bentonite as required until it is a smooth, thick cream, similar to pancake batter, which is as heavy as it is feasible to pump.

4. Insert the grout pipe (if a sacrificial pipe was not previously in place) into the grout pipe opening (typically 28.6 mm or 1.125” in diameter) on the tube mount. Connect the gate valve assembly to the grout pump. It may be advisable to prime the grout tube that is routed to the bottom of the borehole and verify that it is not plugged by pumping water through the line before grouting.

5. Pump the grout into the borehole slowly through the tremie grout pipe, 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 this process. Care should be taken to support the assembly during removal of the augers or casing sections.

6. 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 ideal).

7. After the grout has cured, verify that the grout level is close to the surface by looking down into the hole along side the tube mount assembly (if possible). If the grout has recessed it is recommended to top off the borehole with grout or, if relatively shallow, fill with the cement.

4.12.2 HYDRAULIC ANCHORS (BLADDER AND BORROS STYLE)

Connect the hydraulic line to a hydraulic pump. One at a time, and starting with the deepest anchor, apply pressure until a steady reading of 1500 psi is obtained for bladder anchors and 2500 psi for borros anchors.

Note: If using a hollow core auger, or if the borehole has been lined with casing, remove the auger/casing from the borehole during this process. Care must be taken to support the assembly during removal of the auger/casing sections.

If the borehole is to be grouted, follow the guidelines in Section 4.12.1.

4.13 SECURE TUBE MOUNT AND REMOVE TEMPORARY HARDWARE

The tube mount and coupler/flange assembly should be locked into the surrounding formation/environment if not already fully secured. This can be done with quick setting (hydraulic) cement. Cement should come up and around the flange or coupling (Figure 33).

Important! It is critical to keep the cement level below the top of the tube mount.

After the cement has fully cured, complete the following.

1. Clean any debris from the top of tube mount.

Important! While the tube mount is exposed it is essential to keep debris away from the top of the tube mount to keep it from getting down inside the rod tubes.

2. Loosen the temporary Swagelok connector nut(s) securing the extension rods to the tube mount.
3. Unscrew and remove the extension rod(s).
4. Remove the temporary Swagelok connector(s).
5. Remove the rope/cable and eye bolt(s) that were used to suspend the extensometer.
6. Remove the green plugs from the remaining threaded holes.
7. Trim the grout tube and hydraulic lines so they are flush or slightly below the face of the tube mount (if applicable).

***FIGURE 33:** Anchor Hardware Removed from Tube Mount, Top Face View*

4.14 INSTALLING THE VIBRATING WIRE TRANSDUCERS

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

1. Align the numbers stamped on the transducer housing with those on the tube mount. Secure together using the cap screws that were previously removed.

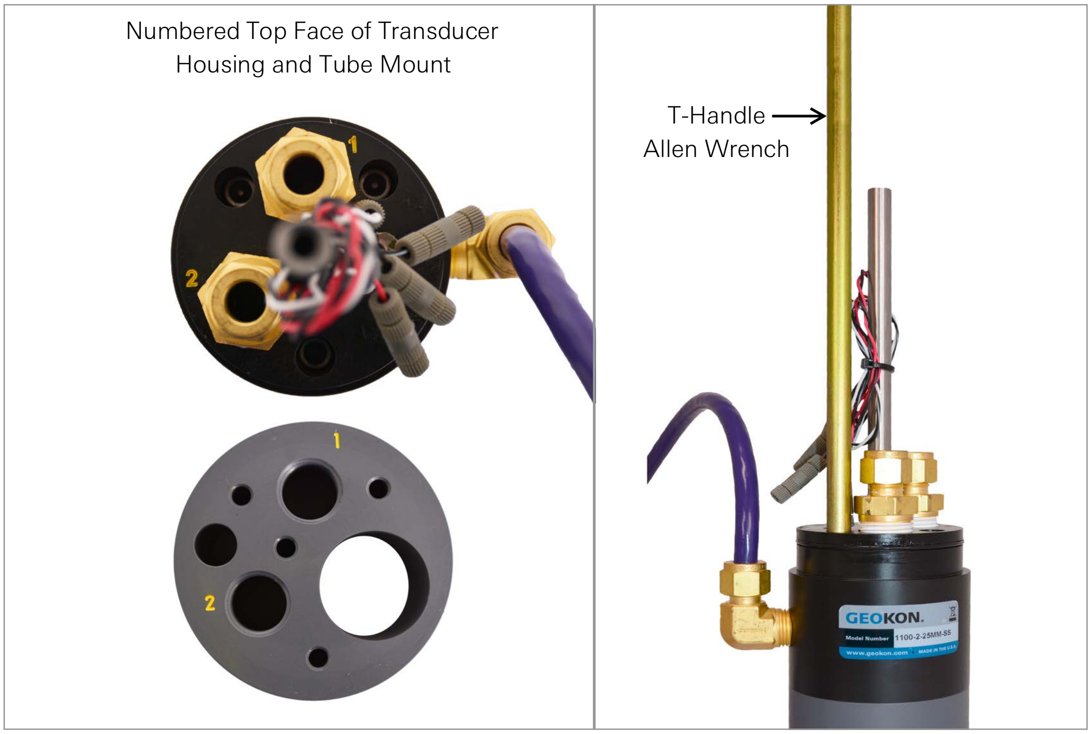

FIGURE 34: Secure Transducer Housing to Tube Mount

2. Select a transducer and record the following:
   - Serial Number of the Transducer.
   - Identification number of the extensometer.
   - Number of the anchor position it will be installed in.

Note: This information will be used for identifying readings and subsequent data reduction. Keeping serial, extensometer, and anchor position numbers sequential is best practice and recommended when possible.

3. Remove the shipping spacer from the transducer. Allow the shaft of the transducer to gently retract until the metal alignment pin that protrudes from the side of the shaft sits in the alignment slot 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 and alignment slot on the body serve as a guide. Never extend the transducer beyond its working range.

Note: Transducers with a range of 100 mm or more come with a lead-in spacer to facilitate the installation and alignment of the transducer and connecting rods.

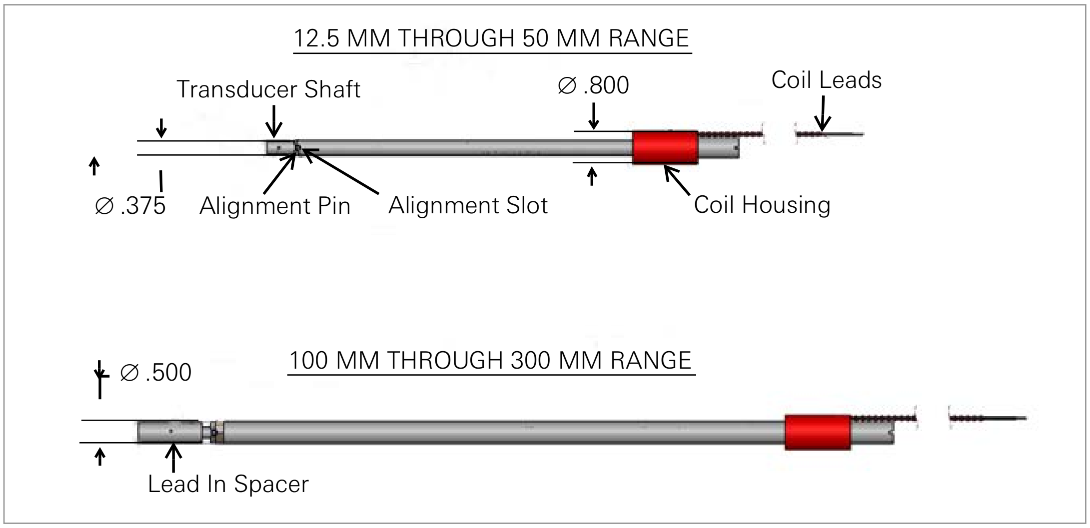

FIGURE 35: *Model 4450 Displacement Transducer*

4. Loosen (but do not remove) the nut of the Swagelok on the anchor position the transducer will be installed in.
5. Push the transducer through the fitting until it touches the end of the connecting rod.

Warning! Before completing Step 6, be sure the alignment pin in the transducer shaft is securely seated in the alignment slot on the transducer housing, otherwise the vibrating wire inside the gauge may break.

FIGURE 36: *Insert Transducer Into Transducer Housing*

6. Rotate the sensor clockwise until it is tight on the connecting rod (about 16 turns).

Warning! Make sure to keep downward force on the transducer while threading it onto the connecting rod so the alignment pin in the transducer shaft doesn't disengage from the alignment slot.

If the transducer is not connecting with the rod below because of a misalignment, unthread the Swagelok from the transducer housing and slide it up on the transducer shaft. This allows more flexibility for better alignment. Thread the Swagelok back in place after the transducer is fully engaged with the rod below.

FIGURE 37: *Thread Transducer Into Internal Rod Column*

7. Connect the leads of the transducer to the leads of the extensometer cable using the provided Posi-Lock Connectors (see figure below for installation steps). Refer to Appendix D for the correct wiring.

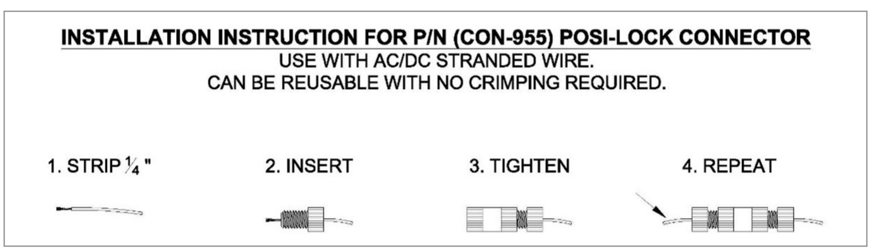

FIGURE 38: *Using Posi-Lock Connectors*

8. Check that all the connections are secure by gently pulling on them.
9. Connect a readout box or datalogger to the head assembly cable. (For compatible readouts see Section 5, for wiring charts see Appendix D.)
10. Gently pull up on the transducer shaft (Figure 39) until the desired reading is obtained.

    The transducer range is approximately 4,000 digits of change, typically starting at 2,500 and ending at 6,500 (plus some over-range capability). Use the guidelines in table below. Consult individual calibration sheets for exact readings.

Mid-Range	1/3 Compression, 2/3 Extension	2/3 Compression, 1/3 Extension
4.500 digits	3,500 digits	5,500 digits

TABLE 7: *Transducer Setting Ranges*

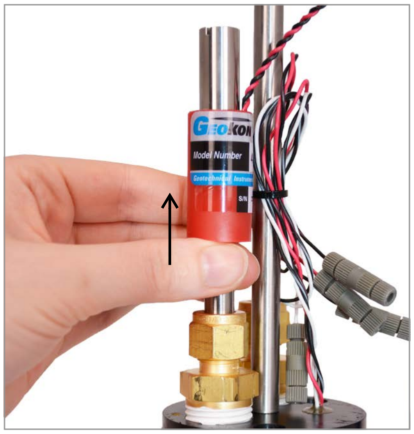

FIGURE 39: *Pull Up On Transducer*

11. While holding the transducer shaft in the desired position, tighten the nut on the Swagelok fitting.

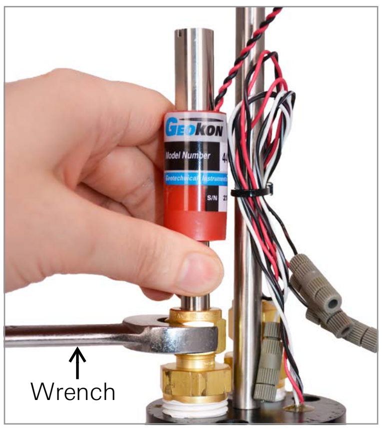

FIGURE 40: *Set Transducer*

12. Repeat the above process for the remaining transducers.

4.15 INSTALL THE PROTECTIVE COVER

Reinstall the protective cover over the transducer housing and secure using the cap screw(s) removed previously (Figure 41).

FIGURE 41: *Secure the Protective Cover to the Transducer Housing*

5. TAKING READINGS

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.

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. For MPBX models designed for electronic and manual readout, when a rod is pulled the transducer shaft will retract, and the vibrating wire reading will decrease.

5.1 COMPATIBLE READOUTS AND DATALOGGERS

GEOKON can provide several readout and datalogger options. Devices compatible with this product are listed below. For further details and instruction consult the corresponding Manual(s) at geokon.com/Readouts and geokon.com/Dataloggers.

Readouts

DIGITAL READOUTS:

- **GK-404**

  The Model GK-404 VW Readout is a portable, low-power, hand-held unit capable of running for more than 20 hours continuously on two AA batteries. It is designed for the readout of all GEOKON Vibrating Wire instruments, and is capable of displaying the reading in digits, frequency (Hz), period (µs), or microstrain (µε). The GK-404 displays the temperature of the transducer (embedded thermistor) with a resolution of 0.1 °C.

- **GK-406**

  The Model GK-406 is a field-ready device able to quickly measure a sensor, save data, and communicate results with custom PDF reports and spreadsheet output. Measurements are geo-located with the integrated GPS allowing the GK-406 to verify locations and lead the user to the sensor locations. The large color display and VSPECT™ technology create confidence of getting the best measurement possible both in the field and in the office.

Dataloggers

DATALOGGERS:

- **8600 Series**

  The MICRO-6000 Datalogger is designed to support the reading of a large number of GEOKON Vibrating Wire instruments for various unattended data collection applications through the use of GEOKON Model 8032 Multiplexers. Weatherproof packaging allows the unit to be installed in field environments where inhospitable conditions prevail. The Nema 4X enclosure also has a provision for locking to limit access to responsible field personnel.

- **8800 and 8900 Series**

  The GeoNet Wireless Mesh Data Acquisition system consists of a Gateway and subordinate Wireless Mesh Data Loggers that transmit data collected from the connected sensors. The Gateway controls the network and is the aggregator of all the data from the Loggers in the system. The Cellular and Wi-Fi Gateways transfer the collected data to the GEOKON Cloud data storage platform, where it is securely stored and can be viewed in GEOKON Agent Software or exported to a third-party software platform through the Open API. A Local Gateway (no cellular or Wi-Fi capabilities) is available for applications where the data is to remain local or a third-party modem or ethernet connection is desired.

- **8920, 8930, and 8950 Series**

  GEOKON Model 8920, 8930, and 8950 Series Loggers offer a high-value, networked data collection option for all GEOKON Vibrating Wire instruments and digital sensor (MEMS IPI and VW) strings. Each logger comes from the factory ready for deployment and may commence with data acquisition in minutes.

  Sensor data is collected and transferred via a cellular, Wi-Fi, or satellite network to a secure cloud-based storage platform where it can be accessed through the GEOKON OpenAPI. Industry leading data visualization software, such as Vista Data Vision, or the free GEOKON Agent program can be used with the OpenAPI for data viewing and reporting. Commissioning, billing and configuration are accomplished via the easy-to-use GEOKON API Portal.

- **8940 Series**

  GEOKON Model 8940 Series Dataloggers offer a high-value data collection option for all GEOKON Vibrating Wire instruments and digital sensor strings. Waterproof single and four-channel GeoNet dataloggers housed inside rugged PVC enclosures are also available. Each logger is ready to be installed from the factory and acquires data in minutes.

  Sensor data is collected on site by connecting the 8940 to a P.C. and using the free GEOKON Agent software program for data viewing and reporting.

5.2 MODEL 4999 TERMINAL BOXES

Terminal boxes with sealed cable entries are available from GEOKON. 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.

Model 4999 Manual

Terminal Boxes make it easy to manually connect a Readout Box (GK-404 or GK-405). The rotary switch is used to select which "channel" or sensor is being read by the Readout Box.

For further details and instruction consult the Model 4999 Instruction Manual.

5.3 MEASURING TEMPERATURES

All GEOKON vibrating wire instruments are equipped with a thermistor for reading temperature, each extensometer has a single thermistor. In a head assembly with side-exit cable the thermistor is located in the elbow fitting, and with a top-exit cable it will be located just inside the protective cover. The thermistor gives a varying resistance output as the temperature changes. The white and green leads of the instrument cable are normally connected to the internal thermistor.

The thermistor measures temperature at it's location in the head assembly. Measuring temperatures at the head assembly does not provide an indication of what the rods are experiencing down hole. The thermistor does not read temperature in the borehole (along the rods) unless custom designed products are requested.

The GK-404 and GK-406 readouts will read the thermistor and display the temperature in degrees Celsius.

USING AN OHMMETER TO READ TEMPERATURES:

Connect an ohmmeter to the green and white thermistor leads coming from the instrument. Since the resistance changes with temperature are large, the effect of cable resistance is usually insignificant. For long cables a correction can be applied equal to approximately 48.5Ω per km (14.7Ω per 1000') at 20 °C. Multiply these factors by two to account for both directions

Look up the temperature for the measured resistance in Appendix C.

6. DATA ANALYSIS

Raw data can be treated in several ways to reveal zones or planes of weakness in which movement is occurring. All raw data must be converted into time plots as soon as possible. Failure to plot the data in a timely manner can negate the purposes of the monitoring program. Inspection of the plots will show whether movements are steady, are accelerating, or have stopped. They may suggest the need for remedial measures and will be useful in monitoring their efficacy.

EXAMPLE:

Below is an example for a situation where the deep anchor is in stable ground.

Table 8 shows a series of entries into a field book. **In this example, Anchor 3 is located in stable ground.**

Date	Anchor 3 (Depth 20 m) Displacement in millimeters	Anchor 2 (Depth 10 m) Displacement in millimeters	Anchor 1 (Depth 3 m) Displacement in millimeters	Remarks
12/01/00	38.10	25.19	34.75	Initial Reading (R_0)
12/02/00	38.91	26.01	35.51	
12/03/00	39.01	26.11	35.61	
12/05/00	39.12	26.16	35.61	
12/06/00	39.14	26.16	35.61	
12/08/00	40.18	27.13	36.58	Blasting in the area
12/09/00	40.13	27.18	36.63	
12/10/00	40.26	27.31	36.65	
12/11/00	40.64	27.61	36.65	
12/15/00	43.82	28.58	36.83	Heavy rain
12/16/00	43.87	28.58	36.83	
12/18/00	43.94	28.63	36.88	
12/20/00	43.99	28.65	36.88	

TABLE 8: *Raw Data*

The first task is to calculate the measured displacements between the head and each anchor. This can easily be done for each anchor, by subtracting the initial reading, R_0 from each of the subsequent readings. This creates the table of figures shown in Table 9.

Date	Anchor 3 (Depth 20 m) Difference in millimeters	Anchor 2 (Depth 10 m) Difference in millimeters	Anchor 1 (Depth 3 m) Difference in millimeters	Remarks
12/01/00	0.00	0.00	0.00	Installed
12/02/00	0.81	0.82	0.76	
12/03/00	0.91	0.92	0.86	
12/05/00	1.02	0.97	0.86	
12/06/00	1.04	0.97	0.86	
12/08/00	2.08	1.94	1.83	Blasting in the area
12/09/00	2.03	1.99	1.88	
12/10/00	2.16	2.12	1.90	
12/11/00	2.54	2.42	1.90	
12/15/00	5.72	3.39	2.08	Heavy rain
12/16/00	5.75	3.39	2.08	
12/18/00	5.84	3.44	2.13	
12/20/00	5.89	3.46	2.13	

TABLE 9: *Relative Movement Between the Instrument Head and Each Anchor*

However, in the example chosen, it is the deepest anchor that is stable, not the Instrument Head, so that the movement of each of the anchors should be calculated relative to Anchor 3 and not to the instrument head. Immediately it will be realized that the apparent movement of Anchor 3 is actually the absolute movement of the instrument head relative to stable ground.

When the Instrument head is located in stable ground, such as would be the case for a head located at street level in a borehole drilled downwards to terminate slightly above a tunnel being excavated below, then the measured movements on each anchor are taken directly from the readings on each anchor. The analysis of the data would then proceed as before **without the need for the steps described below.**

Date	Anchor 2 (Depth 10 m) Difference in millimeters	Anchor 1 (Depth 3 m) Difference in millimeters	Instrument Head Difference in millimeters	Remarks
12/01/00	0.00	0.00	0.00	Installed
12/02/00	0.01	0.05	0.81	
12/03/00	0.01	0.05	0.91	
12/05/00	0.05	0.16	1.02	
12/06/00	0.07	0.18	1.04	
12/08/00	0.14	0.25	2.08	Blasting in the area
12/09/00	0.04	0.15	2.03	
12/10/00	0.04	0.26	2.16	
12/11/00	0.12	0.64	2.54	
12/15/00	2.33	3.64	5.72	Heavy rain
12/16/00	2.36	3.67	5.75	
12/18/00	2.40	3.71	5.84	
12/20/00	2.43	3.76	5.89	

***TABLE 10:** Movement of the Instrument Head and Anchors Relative to Anchor 3 in Stable Ground*

The data shown in Table 10 could be plotted and shown in a graph like the one shown in Figure 42.

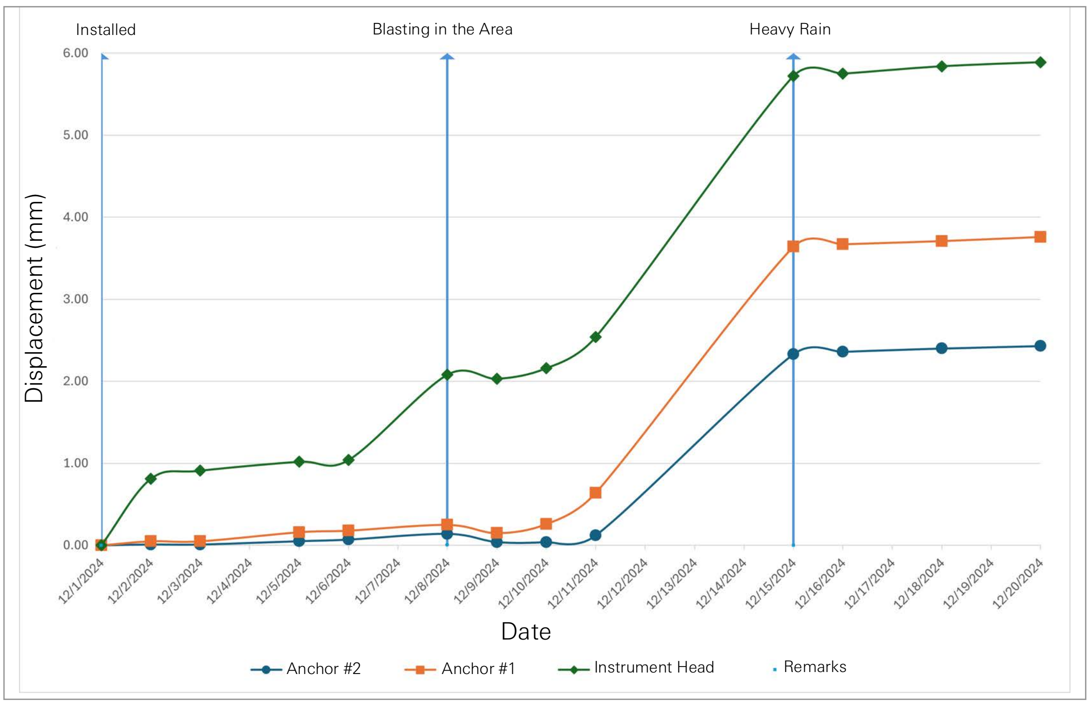

***FIGURE 42:** Movement of the Instrument Head and Anchors Relative to Anchor 3 in Stable Ground*

Inspection of the plot shows that initial movement occurred in the zone closest to the surface during the first three days and again on day eight following blasting in the area. On day 15, following a heavy rainfall, deep-seated movements occurred in the zone between Anchors 2 and 3 as well as in the shallower zones. Movements occurring in any inter-anchor zone can be inferred from the spacing between the individual plots of Figure 42, or they can be plotted separately as shown in Figure 43.

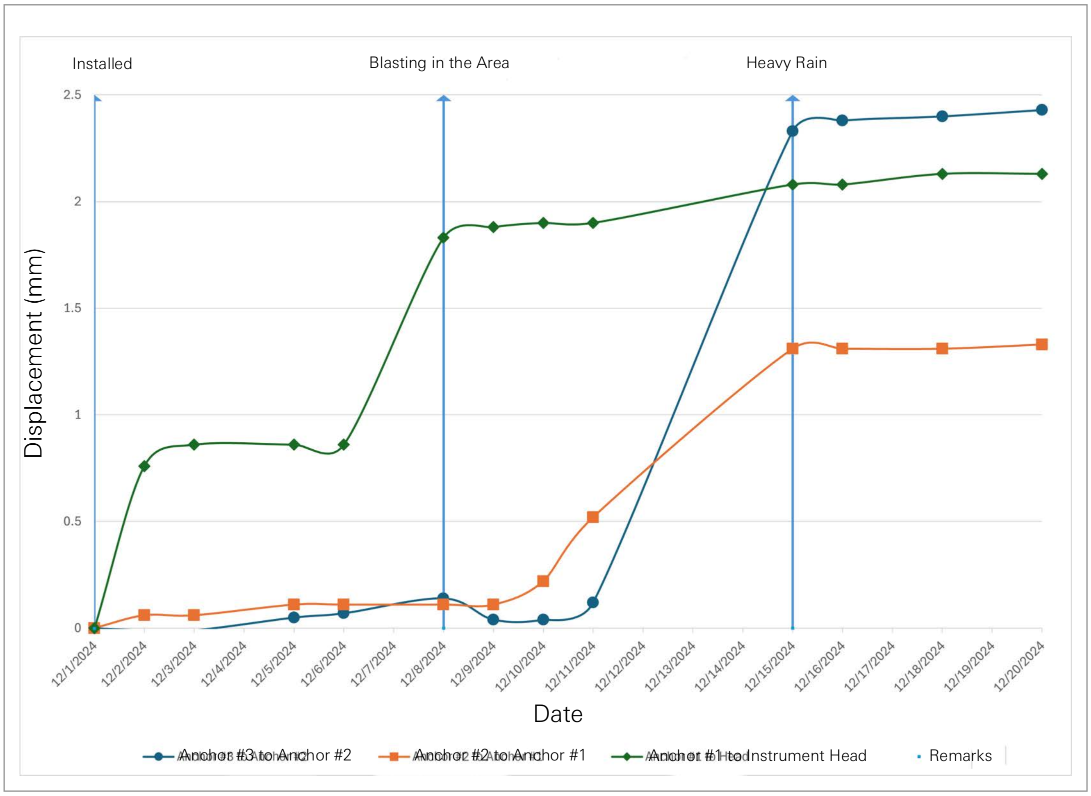

FIGURE 43: *Movements Occurring in Each Inter-Anchor Zone*

7. TROUBLESHOOTING

Technical Support

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 visit geokon.com/Technical-Support.

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 3.4.

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 35) 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 instructions in Section 3.4.
- ☐ 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 11: *Extensometer Specifications*

[1] Other ranges available on request.

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

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 12: *Rod Specifications*

A.3 MODEL 4450 VIBRATING WIRE TRANSDUCER SPECIFICATIONS

Standard Ranges[1]	12.5, 25, 50, 100, 150, 200, 300 mm
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 13: *Model 4450 Vibrating Wire Transducer Specifications*

[1] Other ranges 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 can be calculated using Figure 44 and Table 14.

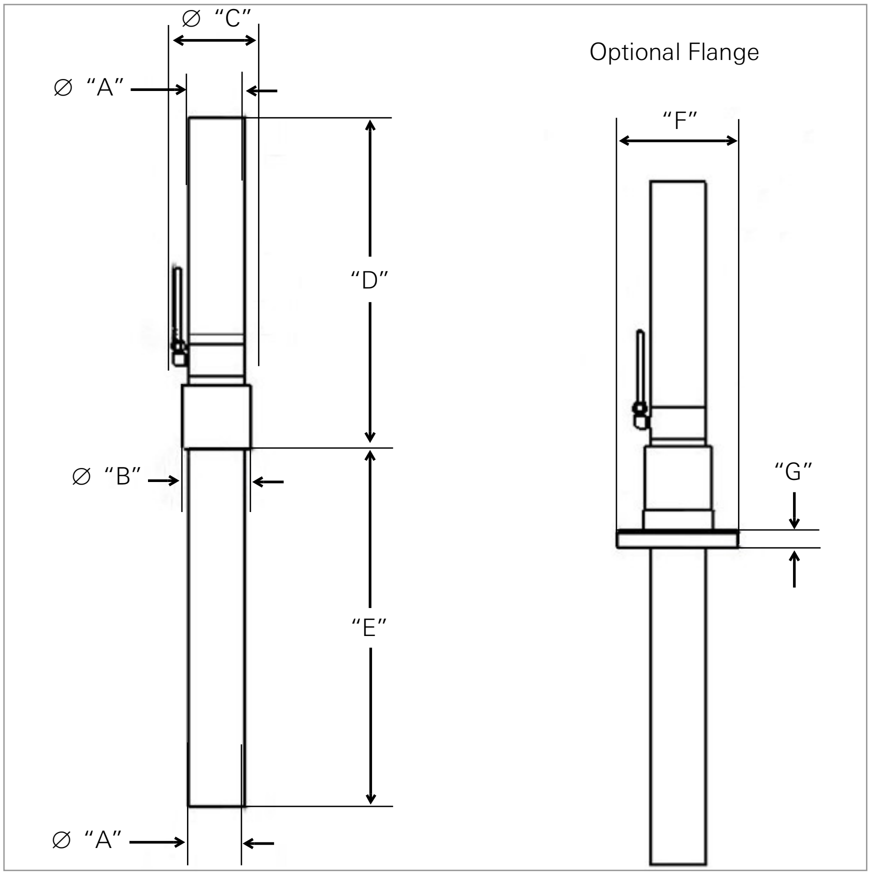

FIGURE 44: *Head Assembly Dimensions Reference Print*

# of 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 14: *Head Assembly Dimensions*

A.5 PARTS LIST

Part Number	Description
1100-#-#-FIB/SS	Extensometer Head Assembly (Cover, transducer housing, tube mount)
 1100-GROUTABLE-FIB/SS 1100-BLADDER-#-FIB/SS 1100-S-BORROS-FIB/SS 1100-D-BORROS-FIB/SS	**Anchor(s):** Groutable Hydraulic Bladder Hydraulic Borros Double Hydraulic Borros
1100-SLIP-FIB/SS-#	Slip Coupling
1100-#-COUPLING/FLANGE	Standpipe with Coupling/Flange included
A1150-105	Extension Rod
B1100-24-# (SS) B1100-25-# (FIB)	Guide Tube Assembly
4450-#-#	Vibrating Wire Displacement Transducer
HRD-A1686	Eye Bolt
HRD-A1722	Green Plug
ROD-101 and TUB-101 ROD-104 and TUB-103	Stainless Steel Connecting Rods/Tubing (includes couplings) Fiberglass Connecting Rods/Tubing
SWG-351B	Swagelok Connector

TABLE 15: *Model 1100-#-#-SS/FIB Parts List*

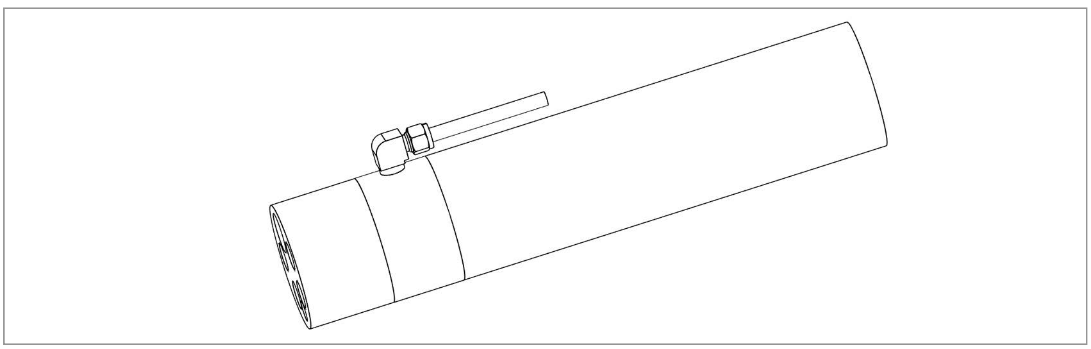

FIGURE 45: *Model 1100-#-#-FIB/SS Extensometer Head Assembly (Tube Mount, Transducer Housing, Cover)*

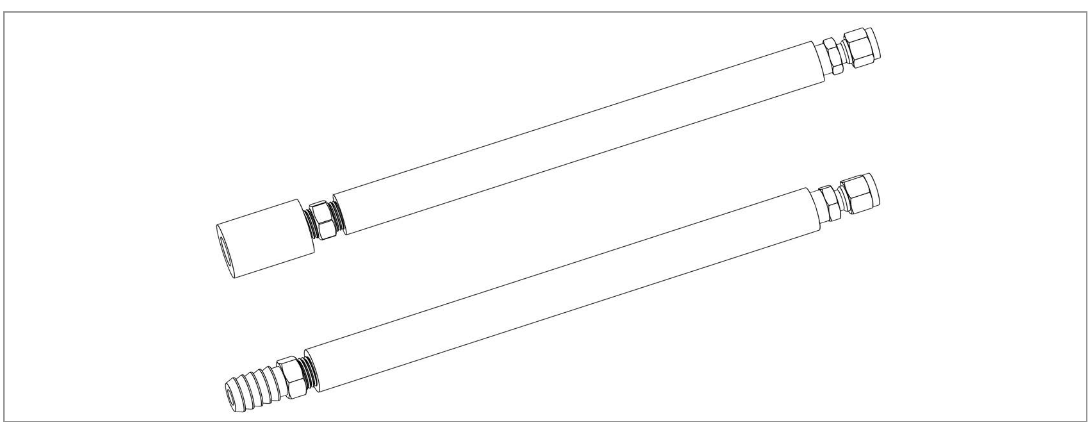

FIGURE 46: *Model 1100-GROUTABLE-SS/FIB Groutable Anchors, Stainless Steel (Top), Fiberglass (Bottom)*

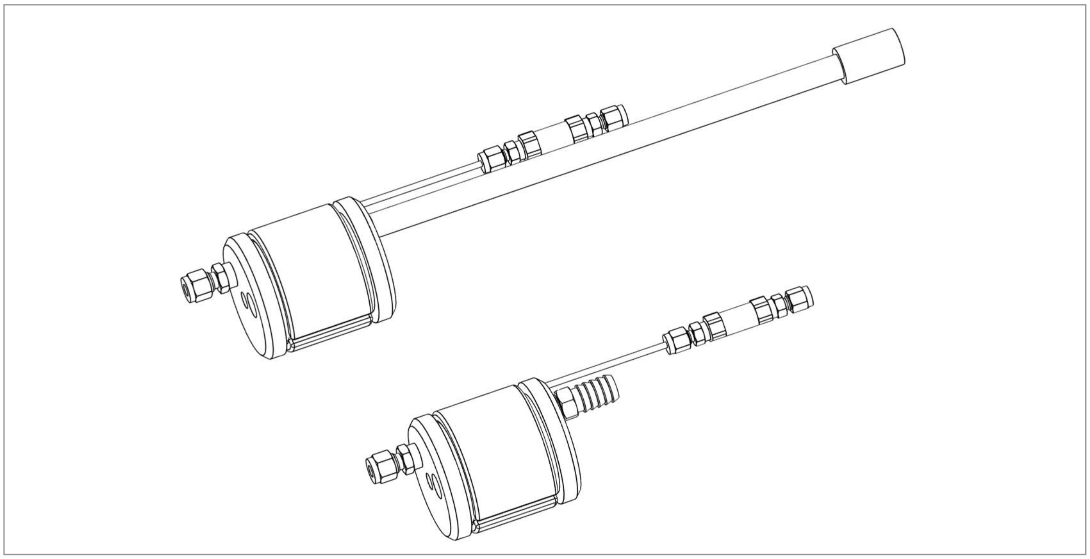

FIGURE 47: *Model 1100-BLADDER-#-SS/FIB Hydraulic Bladder Anchors, Stainless Steel (Top), Fiberglass (Bottom)*

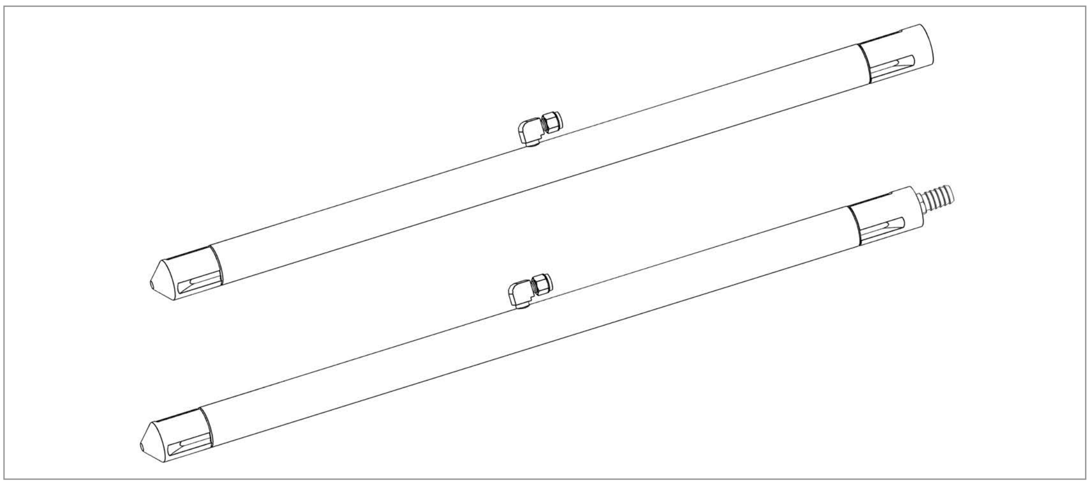

FIGURE 48: *Model 1100-D-BORROS-SS/FIB Hydraulic Double Borros Anchors, Stainless Steel (Top), Fiberglass (Bottom)*

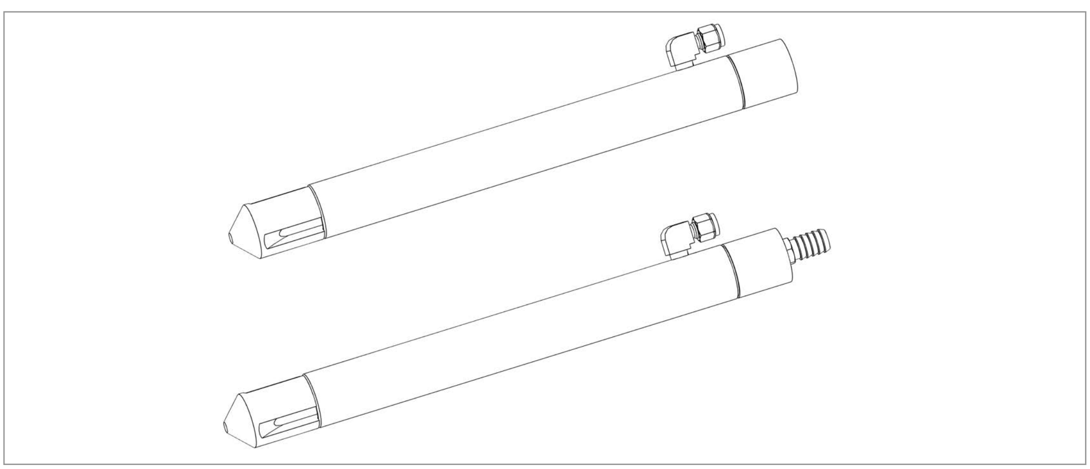

FIGURE 49: *Model 1100-S-BORROS-SS/FIB Hydraulic Single Borros Anchors, Stainless Steel (Top), Fiberglass (Bottom)*

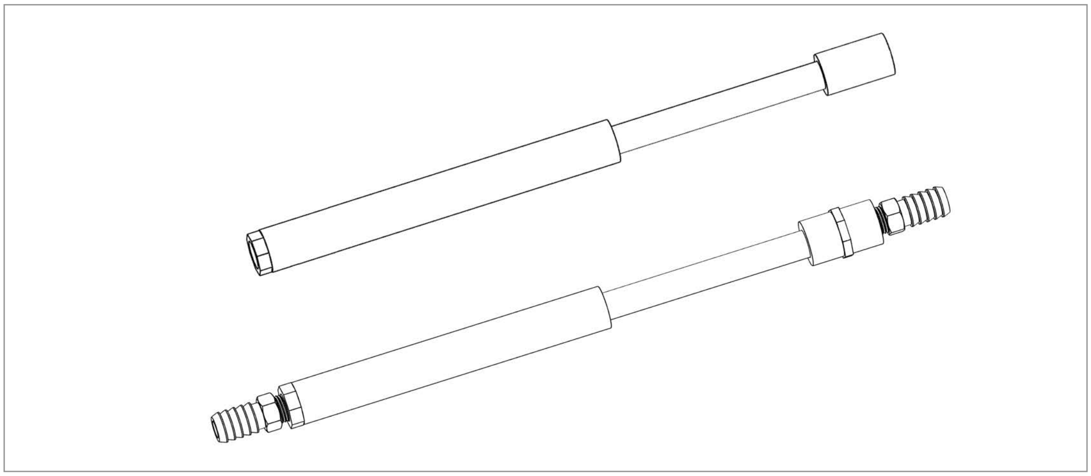

FIGURE 50: *Model 1100-SLIP-SS/FIB-# Slip Couplings, Stainless Steel (Top), Fiberglass (Bottom)*

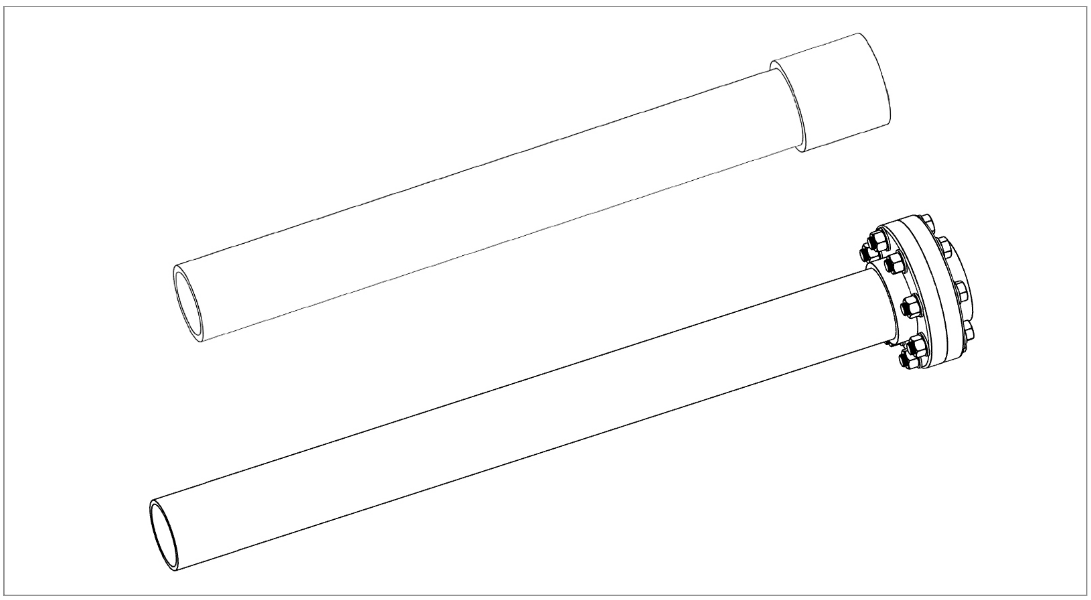

FIGURE 51: *Model 1100-#-COUPLING/FLANGE Standpipe with Coupling (Top) or Flange (Bottom) Included*

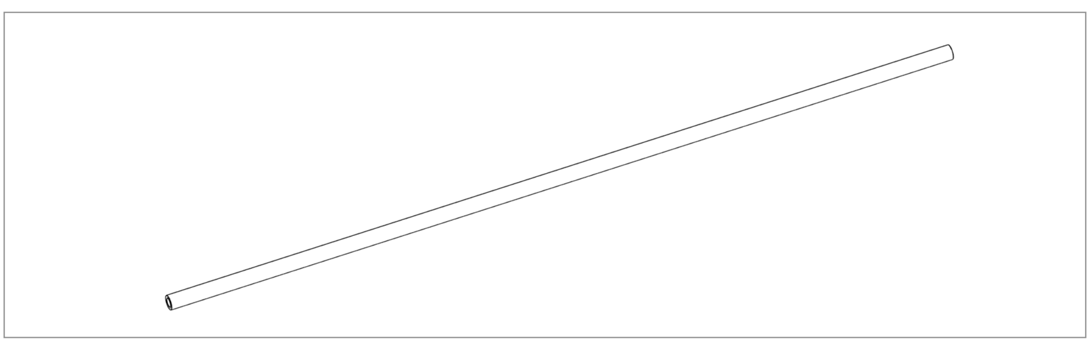

FIGURE 52: *Model A1150-105 Extension Rod*

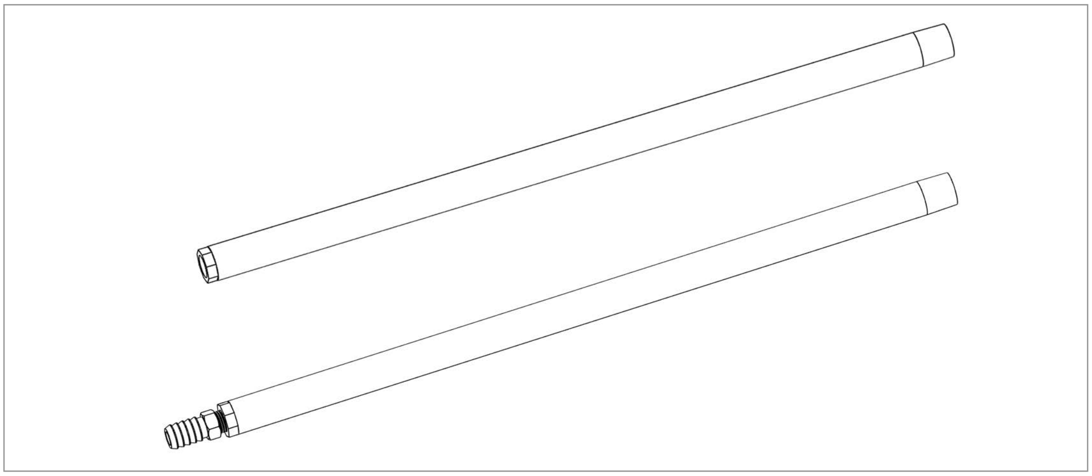

FIGURE 53: *Model B1100-24-# (Stainless Steel, Top) and B1100-25-# (Fiberglass, Bottom) Guide Tube Assembly*

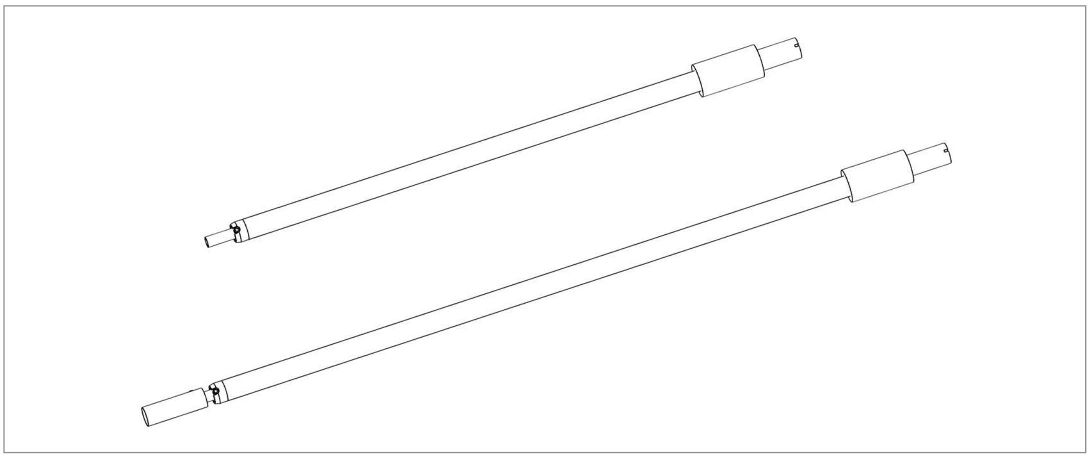

FIGURE 54: *Model 4450-#-# Vibrating Wire Displacement Transducer*

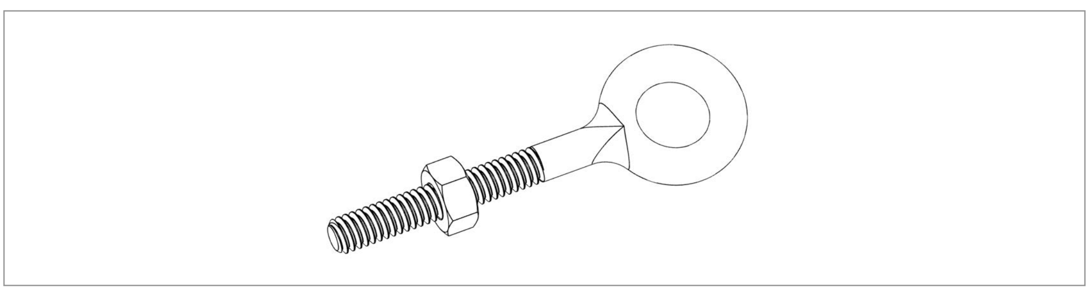

FIGURE 55: *Model HRD-A1686 Eye Bolt*

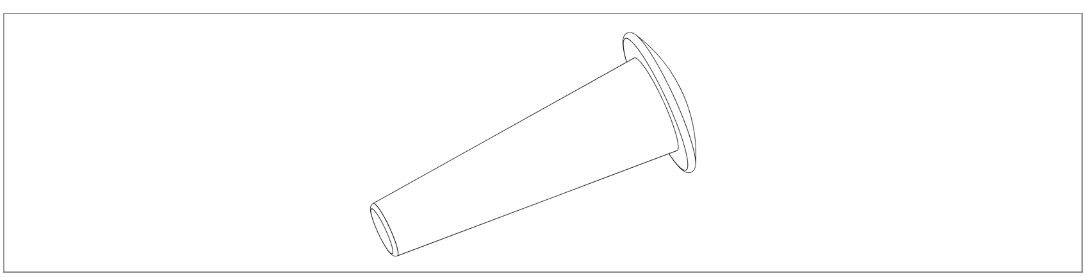

FIGURE 56: *Model HRD-A1722 Green Plug*

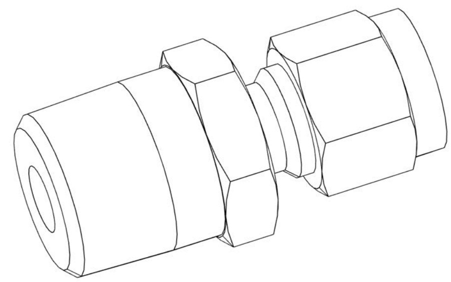

FIGURE 57: Model SWG-351B Swagelok Connector

A.6 TOOLS LIST

See the tables below for a breakdown of toolkits and accessories.

Part Number	Description	Quantity
ADH-103	Loctite 271 Thread locker	1
SUP-802	Black Electrical Tape	2
SUP-814	Fiber Tape	2
TLS-100	1/4 inch x 4 inch Flat Head Screwdriver	1
TLS-106	#2, 4 inch Phillips Head Screwdriver	1
TLS-205	Long 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	Handle for Hand File	1
TLS-601	Acid Brush (144 count Pack)	12
TLS-619	20 inch Toolbox	1

***TABLE 16:** Model 1100-TOOLKIT (Set of Installation Tools)*

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

***TABLE 17:** Model 1100-RECESSED-TOOLS (Accessories for recessed installations)*

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

***TABLE 18:** Model 1100-GROUT-DOWN (Accessories for inclined downward 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

***TABLE 19:** Model 1100-GROUT-UP (Accessories for overhead/upward installations)*

APPENDIX B. EXTENSOMETER ROD TABLE

EXTENSOMETER ROD TABLE

CUSTOMER:	XXX
JOB NUMBER:	XXX
DUE DATE:	XXX
GAGE TYPE:	V.W. TRANSDUCER 25MM (1in.) RANGE
MODEL NUMBER:	1100-3-25MM-SS
QUANTITY:	1

POINT NUMBER	ANCHOR DEPTHS	ANCHOR TYPE	ROD-101 (A7004-26-#) Connecting Rod Lengths		TUB-101 (A1151-5) + PVC-105 1/4in. PVC PIPE + Coupling		ADDITIONAL COMMENTS
			Short Rod Length (in.)	60 in.	60 in.		
1	10 ft.	Groutable (1100-GROUTABLE-SS)	45.250	1	2		
2	20 ft.	Groutable (1100-GROUTABLE-SS)	45.250	3	4		
3	30 ft.	Groutable (1100-GROUTABLE-SS)	45.250	5	6		
			TOTALS	9	12		

FIGURE 58: *Extensometer Rod Table Sample*

APPENDIX C. THERMISTOR TEMPERATURE DERIVATION

C.1 3KΩ THERMISTOR RESISTANCE

Thermistor Types include YSI 44005, Dale #1C3001–B3, Alpha #13A3001–B3, and Honeywell 192–302LET–A01.

Resistance to Temperature Equation:

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

EQUATION 1: *3KΩ Thermistor Resistance*

Where:
T = Temperature in °C
LnR = Natural Log of Thermistor Resistance
A = 1.4051×10^{-3}
B = 2.369×10^{-4}
C = 1.019×10^{-7}
Note: Coefficients calculated over the –50 to +150 °C span.

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

TABLE 20: *3KΩ Thermistor Resistance*

APPENDIX D. WIRING CHARTS FOR VIBRATING WIRE TRANSDUCERS

Model 1450 Manual

See the tables below for wiring charts dependent on the quantity of transducers.

Wiring is different for extensometers with Model 1450 DC-DC LVDT Transducers installed. Refer to the Model 1450 Instruction Manual.

Internal Wiring	GEOKON **Cable #02-250V6 (Blue)**	**Function/Description**
Red	Red	Gauge 1+
Black	Black	Gauge 1-
White	White	Thermistor
Green	Green	Thermistor
N/C	Shield (1)	Ground

TABLE 21: *Wiring for One Transducer*

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-
Blue	Blue	Thermistor
Black of Blue	Black of Blue	Thermistor
N/C	Shields (4)	Ground

TABLE 22: *Wiring for Two Transducers*

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-
Blue	Blue	Thermistor
Black of Blue	Black of Blue	Thermistor
N/C	Shields (5)	Ground

TABLE 23: *Wiring for Three Transducers*

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-
Yellow	Yellow	Thermistor
Black of Yellow	Black of Yellow	Thermistor
N/C	Shields (6)	Ground

TABLE 24: *Wiring for Four Transducers*

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-
Brown	Brown	Thermistor
Black of Brown	Black of Brown	Thermistor
N/C	Shields (7)	Ground

TABLE 25: *Wiring for Five Transducers*

Internal Wiring	GEOKON **Cable #12-625V5 (Brown)**	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 26: *Wiring for Six Transducers*

APPENDIX E. SWAGELOK TUBE FITTING INSTRUCTIONS

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

E.1 INSTALLATION

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

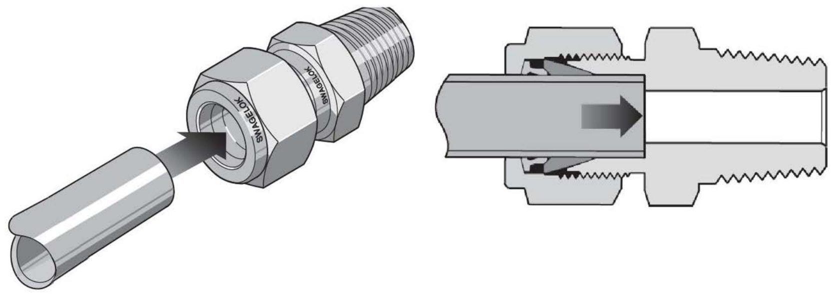

__FIGURE 59:__ Tube Insertion

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.

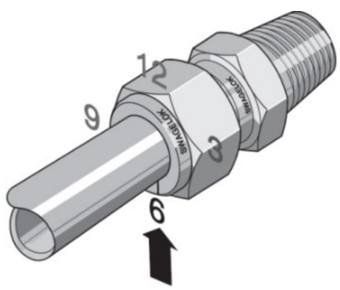

__FIGURE 60:__ Make a Mark at Six O'clock

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.

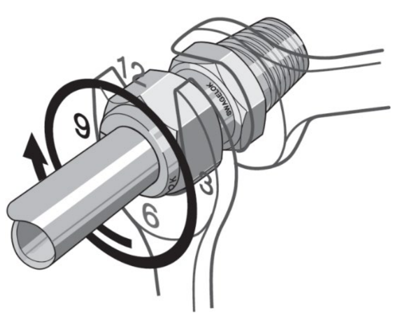

__FIGURE 61:__ Tighten One and One-Quarter Turns

E.2 REASSEMBLY INSTRUCTIONS

Swagelok tube fittings may be disassembled and reassembled many times.

Warning! 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 62: *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.

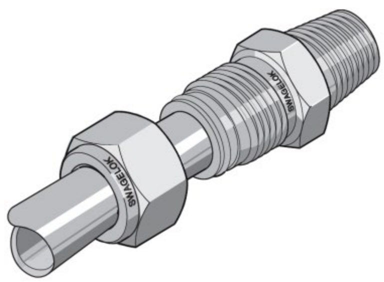

FIGURE 63: *Ferrules Seated Against Fitting Body*

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.

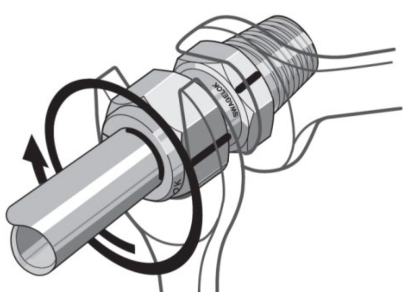

FIGURE 64: *Tighten Nut Slightly*

APPENDIX F. GUIDE TO ORDERING EXTENSOMETERS

Ordering Information for 1100 Series Standard Extensometer. See Section 2 for a detailed description of each component.

1. Extensometer Head Assembly:

Select one option from the table below for each letter (A, B and C) to determine the basic components of the Head Assembly. This is also the part number of the extensometer: **1100-A-B-C**.

Example: The part number of an extensometer with 3 measurement points, 50 mm range transducers, and stainless steel rods is **1100-3-50MM-SS**.

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

TABLE 26: *Extensometer Options*

2. Anchor Type:

Select the anchor(s) needed from the options below.

Part Number	Description
1100-GROUTABLE	Groutable anchor
1100-BLADDER	Hydraulic bladder anchor with check valve
1100-S-BORROS	Hydraulic single action borros anchor
1100-D-BORROS	Hydraulic double action borros anchor

TABLE 27: *Anchor Options*

3. Anchor depths:

Designate depths from installation surface to tip of anchor for each anchor. See Section 3.3 for more information about anchor spacing.

Anchor #1 ______ Anchor #2 ______ Anchor #3 ______

Anchor #4 ______ Anchor #5 ______ Anchor #6 ______

4. Accessories and Tool Kits:

Accessory Category	Part Number	Description	Additional Information
Grout Tube	TUB-104-E (english)	O.D. of 19 mm (0.75 inch)	Indicate Length: _________
	TUB-104-M (metric)		
Installation Tools	1100-#-#-KIT	Installation kit with extension rods.	Measurement points ______ Transducer range _______ Number of kits required equals maximum number of extensometers to be installed in a single day.
	1100-TOOLKIT	Set of installation tools	N/A
	1100-RECESSED-TOOLS	Additional tools required for recessed installations.	N/A
Grouting Tools	1100-GROUT-DOWN	Set of grouting accessories for inclined downwards installations.	N/A
	1100-GROUT-UP	Set of grouting accessories for overhead/upward installations.	One set of GROUT-UP accessories may be required per each overhead extensometer.
Hydraulic Pump and Hose	1100-PUMP	Hydraulic pump with quick connect for inflating hydraulic anchors	N/A
Standpipe	1100-#-COUPLING	2.5 ft (0.75 m) long standpipe. Comes with coupling.	"#" corresponds with the number of points in the extensometer.
	1100-#-FLANGE	2.5 ft (0.75 m) long standpipe. Comes with flange.	"#" corresponds with the number of points in the extensometer.

TABLE 27: *Accessories and Tool Kits*

5. Additional Considerations:

■ Location of the Head Assembly: Refer to the table below.

Location of the Head Assembly	Additional Information	Description
Protruding	N/A	See Section 3. Location is used for calculating correct connecting rod, PVC pipe or tubing lengths.
Recessed 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		

TABLE 27: *Location of the Head Assembly*

■ Grouting: Will the borehole be grouted?

- ☐ Yes
- ☐ No

■ General Information, consider site conditions and shipping method:

- ☐ 6 mm (1/4 inch) Rod: Standard rod length is 3 m (10 feet). Optional rod lengths 1.5 m (5 feet).
- ☐ 6 mm (1/4 inch) PVC Pipe: Standard PVC pipe length is 3 m (10 feet). Optional rod lengths 1.5 m (5 feet).

GEOKON
48 Spencer Street
Lebanon, New Hampshire
03766, USA

Phone: +1 (603) 448-1562
Email: info@geokon.com
Website: www.geokon.com